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Three-Cylinder Simple 4-4-0 Type Locomotives

A Refined Design for Passenger Service on the London & North Eastern Railway

A new design of three-cylinder simple locomotive of the 4-4-0 type has recently been constructed in the shops of the London & North Eastern Railway at Darlington, England. They are known as the Class D-49 of the road and are named after the "Shires." They will be used on the Company's lines in the Northeast of England and in Scotland and are to be used in express passenger service other than the heaviest of main-line trains. Twenty-eight are under construction.

American or 4-4-0 Type Three-Cylinder Locomotive of the London & North Eastern Railway

The illustration shows No. 234, the "Yorkshire," and we are indebted to the designer, Mr. H. N. Gresley, chief mechanical engineer of the London & North Eastern for the details here given in regard to them. They are the heaviest and most powerful of the 4-4-0 wheel arrangement that has ever been built in Britain, the tractive effort being 21,566 lbs., at 85 per cent of the boiler pressure.

Three cylinders, simple acting, are 17 in. in diameter with a stroke of 26 in., and are arranged horizontally in line above the truck centre. Piston valves 8 in. diameter with a maximum travel of 6 in. are actuated by Walschaerts valve gears for the outside cylinders, and by Gresley gear for the inside valve, the levers for driving the latter being arranged behind the cylinders and operated by the outside motion.

The valve gear is arranged so that the movement of the inside valve is derived from the combined movement of the two exterior Walschaerts motions, by levers attached to the valve spindles, the radius rods being suitably formed to clear the connection to the rocking levers, when the die-block is in the lower quadrant of the link. These spindles are provided with guides formed upon the valve chamber covers. This arrangement differs from that adopted by Mr. Gresley for the "Pacific," and other three-cylinder engines, where the levers are located in front of the cylinders. The return cranks of the outside gears are fitted with ball-bearing ends. Wakefield mechanical lubricators are employed.

The cylinder horse-power is estimated at 1,403. The steam lap for the outside cylinders is 1⅝ in., and for the inside cylinder 1 11/16 in., the exhaust lap being nil for each; cut-off in full gear is 65 per cent.

The driving wheels are 6 ft. 8 in. diameter with journals 9½ in. by 11 in. The inside crank pins are 8¼ in. by 6 in., and the outside 5½ in. by 8½ in. The driving coupling pins are 8⅝ in. diameter by 3 in. long, and the trailing 4 in. by 4½ in. long.

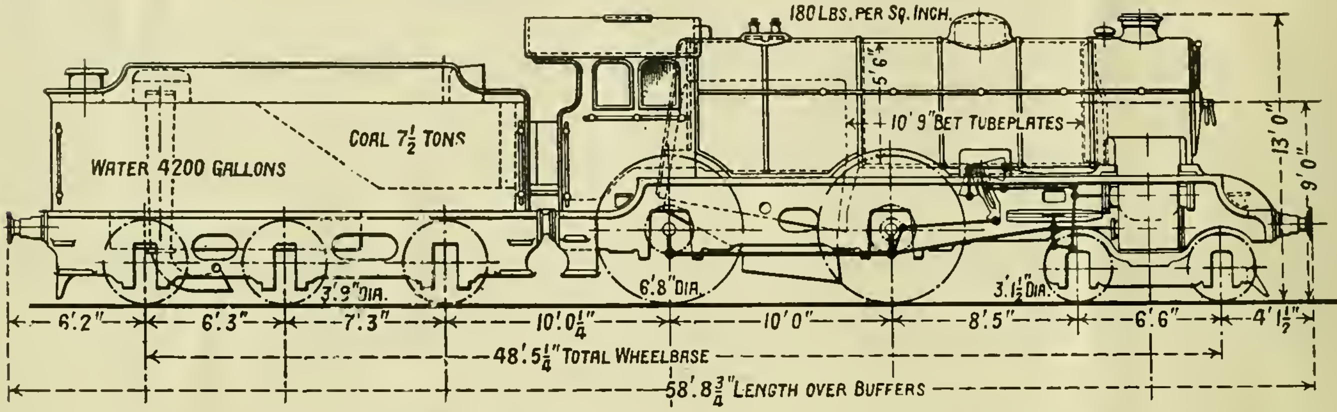
The driving wheels are supported by four laminated springs, 3 ft. 6 in. centres, made up of 11 plates, 5 in. wide by ⅝ in. thick. The weight available for adhesion is 42 tons.

The truck wheels are 3 ft. 1¼ in. diameter, with journals 6½ in. dia. by 10 in. long, and have helical bearing springs of Timmis' section 10 3/16 in. long, free, and 5 1/16 in. outside diameter.

The diameter of the boiler is 5 ft. 6 in., with a barrel 11 ft. 5⅝ in. in length; outside diameter of smokebox 5 ft. 9½ in. and 4 ft. 8¾ in. long. The crown of the firebox is 6 ft. 6 in. above the foundation ring at the front end, and 4 ft. 10½ in. at the back; inside it is 7 ft. 1 5/16 in. long at the top, and 4 ft. 7¾ in. wide at the boiler centre. The outside firebox measures 9 ft. 0 in. long overall, and 8 ft. 6 in. at the bottom, by 4 ft. 0½ in. wide. The sloping grate is 7 ft. 9½ in. in length and 3 ft. 4 in. wide, giving an area of 26 sq. ft. The boiler horsepower is 1,056.

ing surface 1,643.88 sq. ft. The horse-power of the boiler is estimated at 1,056. Two Ross pop safety valves of 2½ in. diameter are provided. The engines are equipped with live steam injectors and also Davies & Metcalfe exhaust steam injectors.

Another feature is the adoption of the "Woodard" design of main and side rods.



London & North Eastern 4-4-0 Type Three-Cylinder Locomotive

With its centre line 9 ft. above rail level the boiler carries a working pressure of 180 lb. per sq. in. and contains 177 small solid drawn steel tubes of 1¾ in. outside

Cylinders (three)—	
Diameter	17 in.
Piston stroke	26 in.
Wheels, coupled, diameter	6 ft. 8 in.
Wheelbase—	
Rigid	10 ft. 0 in.
Engine	24 ft. 11 in.
Engine and tender	48 ft. 5¼ in.
Boiler—	
Diameter of barrel	5 ft. 6 in.
Length of barrel	11 ft. 4⅝ in.
Tubes—	
Small, No.	177
Diameter, outside	1¾ in.
Thickness	11 I.W.G.
Superheater flues—	
Diameter, outside	5¼ in.
Thickness	5/32 in.
Length between tube plates	10 ft. 9 in.
Heating surface—	
Firebox	171.50 sq. ft.
Small tubes	871.75 sq. ft.
Superheater flues	354.53 sq. ft.
Total evaporating heating surface	1,397.78 sq. ft.
Superheater, elements—	
No.	24
Diameter, inside	1 3/32 in.
Heating surface	246.1 sq. ft.
Combined heating surface	1,643.88 sq. ft.
Grate area	26 sq. ft.
Boiler pressure	180 lbs. per sq. in

diameter by 11 I.W.G. thick, and 24 superheater flues 5¼ in. outside diameter by 5/32 in. thick and 10 ft. 9 in. long between tubeplates. The total evaporative heating surface of 1,397.78 sq. ft. is made up as follows: firebox, 171.5 sq. ft.; small tubes, 871.75 sq. ft.; and large flues, 354.53 sq. ft. The 24 element superheater of the Superheater Co.'s latest pattern, elements 1 3/32 in. diameter inside, provides a surface of 246.1 sq. ft., making the total heat-

The ratio of adhesive weight to tractive effort is estimated at 4.36.

The Westinghouse brake is fitted, and a vacuum ejector, for operating train brake.

The six-wheeled tender carries 4,200 gallons of water and 7½ tons of coal.

The tender wheels are 45 in. in diameter, the wheelbase being 13 ft. 6 in. The wheels are disc instead of the usual London & North Eastern standard spoked design. It is equipped with a water scoop.

A summary of the principal details is given in the accompanying table.

Pullman Car Named for Col. Lindbergh

Lindbergh has broken another precedent. Many fanciful names have been applied to sleepers and parlor cars, but the rule observed by such institutions as the Louvre and the Hall of Fame is also followed in the Pullman Company, to honor no living man. Yet the gold letters, "Col. Charles A. Lindbergh," were recently inscribed on the side of a Pullman car.

This departure from the traditional practice is regarded as an indication that the nomenclature of these cars is to become more elastic. In the past, it appears, effort has been concentrated on finding strange and sometimes unpronounceable names to impress rather than to interest the countryside. It is related that several years ago, when the company took over 400 cars from a rival concern and names had to be supplied overnight, officials spent many hours in the Chicago Public Library digging through musty volumes in their research. Painters received the list the following morning and soon 400 cars went journeying forth with new names.

"Loch" is a popular prefix on the sides of Pullman cars, also "Lake" and "Mount." There is a "St. Nicholas" and other saints' names also appear. Some of the cars bear the names of former Presidents of the United States, of artists, musicians and authors. Many objects are represented from flowers to grand operas.

One car bears the name of a Pullman porter who died in a wreck several years ago. He refused assistance until a little girl near him had been cared for, and when the first-aid workers returned to him he was dead. In his honor the Sirocco was rechristened the Daniels.

Weighing Scales on the Pennsylvania Railroad

Over 6000 Weighing Machines Are Employed on the System

In no phase of modern industrial life are scales of greater importance than in the operation of a railroad. This arises from the fact that the revenues derived by a railroad company from its freight traffic are based entirely on weight, as determined by many kinds of scales. When it is remembered that the Pennsylvania Railroad handled 230,000,000 tons of freight last year, the importance of accurate weighing machines in railroad operation may be readily appreciated. As a concrete illustration, the weighing operations on a single track scale—that in the Juniata yard at Altoona, Pa.—determine freight charges of approximately $50,000,000 annually. It will be readily seen that efficiency and dependability of the weighing apparatus are vital necessities in protecting the interests of both shipper and carrier.

Many different types of scales are used on a railroad. The most important are the gigantic track scales on which entire freight cars with their lading are weighed. As the bulk of railroad freight moves in carload lots, most of the weighing is done on these scales of which the Pennsylvania operates 250.

For less-than-car-load shipments, platform scales are provided at all freight stations. A modern and efficient scale known as the "Automatic Indicating Dial" is also used about freight stations for the smaller shipments. Baggage room scales check the weight of trunks and other luggage, while small counter scales are provided at many points for parcels and packages. A total of 6,000 scales of every kind are in service on the Pennsylvania Railroad, and determine a revenue of well over a half-billion dollars annually in normally prosperous times.

In the early days of railroad operation, ordinary wagon scales designed by commercial scale companies for the weighing of wagons and their lading were used to weigh loaded freight cars. As early as 1872, however, the Pennsylvania Railroad had its own master scales and test weight cars for use in checking and keeping accurate the wagon scales out on the line.

The master scales were first adjusted to standard weights verified by the Bureau of Standards at Washington. Test weight cars were then weighed on the master scales and sent out on the road to test the local track scales. The Pennsylvania was the first railroad to adopt the policy of thus checking the accuracy and efficiency of its roadway scales.

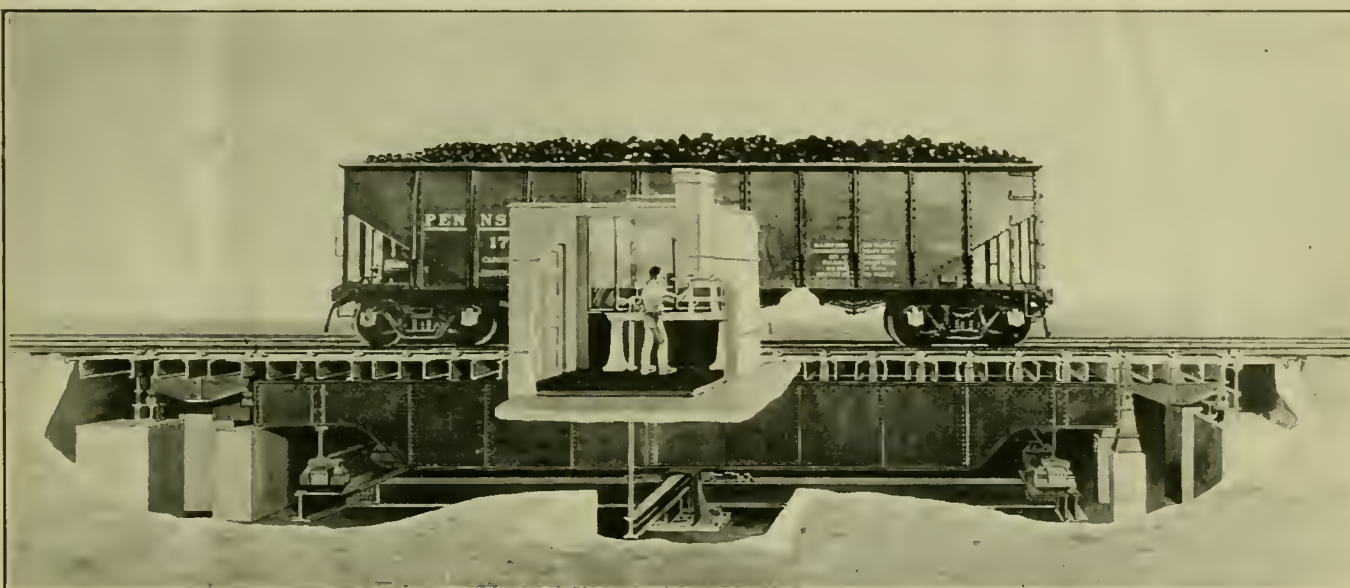
With the coming of heavier cars and locomotives, the railroad saw the necessity of providing more adequate and dependable weighing facilities in the tracks. Scales available on the commercial market not being altogether satisfactory for railroad use, the Company organized its own scale department and shop organization.

Then efforts of the Pennsylvania Railroad scale experts were first centered upon improving the mechanism of track scales as then designed. They were universally based upon the principle of the "knife edge" balance, which had been handed down from the most remote antiquity by the scale makers' art. This form of design at its best, however, proved somewhat unsatisfactory for railroad purposes, because the knife edges would wear perceptibly under heavy service, becoming blunt and irregular, and affecting the accuracy and efficiency of the machine.

After careful study and research, the railroad in cooperation with the Fairbanks Scale Company and the Bureau of Standards at Washington, developed in its own shops, at Altoona, a type of track scale based upon an entirely different principle, known as the "plate fulcrum." In the plate fulcrum scale, the balance is maintained and the load carried on thin vertical plates of steel instead of knife edges. The flexing of these plates within very narrow limits takes the place of the oscillations of the scale beam upon the knife edges employed in older types of scales.

Experience has shown that the plate fulcrum eliminates mechanical friction and that even under prolonged use, no noticeable wear occurs. In consequence, the machine maintains its accuracy indefinitely and without necessity for frequent repairs.

The perfecting of the plate falcrum scale has therefore marked a tremendous advance in the science of weighing



Weighing a Carload of Coal on One of the Pennsylvania Railroad's Plate Fulcrum Track Scales railroad freight cars accurately and efficiently. The success of this type is now demonstrated beyond question as it has stood the test of 12 years' constant service in some of the business terminal yards of the company.

A majority of railroad freight cars are weighed while in motion. Track scales usually are located between the receiving and classification yards in the larger freight terminals and the cars are weighed as they move from one yard to the other in the process of being made up into trains. In this manner weight is determined quickly and efficiently, with but slight delay to the onward movement of the freight. A scale at one of the busier terminal yards has a record of weighing an average of about one and one-half cars every minute throughout an entire month.

The modern type plate fulcrum scale has a weighing capacity of 400,000 pounds, and will support loads of 800,000 pounds. Larger scales of this type cost approximately $70,000.

Despite their tremendous capacity these scales are so sensitive and so delicately adjusted that they can determine the weight of a person within five pounds.

There was recently installed in the Juniata freight yards at Altoona a twin pair of plate fulcrum scales, which, taken together, constitute the largest and most modern plant for weighing carload freight on any railroad. These gigantic weighing machines have a capacity of 800,000 pounds each and cost $128,000.

The working mechanism of track scales is usually installed in roomy underground pits of heavy masonry construction. The weighing beams are placed above ground, enclosed by plate glass bay windows, affording an unobstructed view in all directions. Some idea of the massiveness of scale structures may be gained from the fact that the weight of one of the bridges of the new Juniata scales is seventy-three and one-half tons. An especially designed lighting system makes possible continuous day and night operation. The masonry pits which house the scale machinery are kept heated throughout winter weather, and an even temperature is thermostatically maintained.

The Pennsylvania Railroad was the first to design and build mechanical humps to regulate the speed of cars passing over its track scales. The cars are pushed to the top of the hump by a locomotive and then allowed to descend by gravity across the scale platform. In order that cars may pass over the scales at uniform speed at all seasons of the year, and in varying weather conditions, the humps are so devised that they may be raised or lowered when necessary.

In order that its track scales may be kept at the highest point of efficiency, the railroad operates a number of these weight cars. These cars travel over the entire system covering all scales on a regular schedule. Every track scale is closely checked and tested to develop the most minute defects or inaccuracies. If the scale is slightly off, immediately adjustments are made and complete accuracy restored.

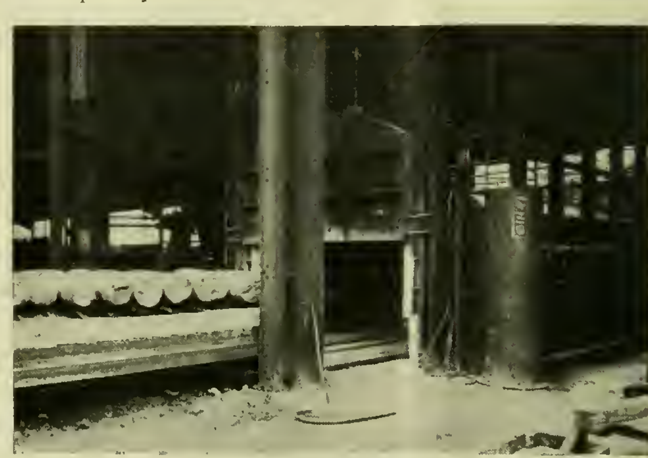
To test the test weight cars, three master scales are maintained. The master scale in the scale shop at Altoona is the most important of these for it is to this scale that most of the test weight cars are sent for checking.

A new master scale has just been designed and built at Altoona for use in the scale shop. This scale is of the plate fulcrum type, the first of its character in existence anywhere. It is undoubtedly the most accurate and efficient instrument of its kind yet devised. It has a capacity of 150,000 pounds. So accurate is this scale that in a recent test it weighed a load of 100,000 pounds with a deviation of only three-tenths of a pound from the exact weight.

In addition to its use in railroad weighing this master scale and its test weight are utilized cars to calibrate and standardize more than 1,000 track scales belonging to industrial concerns located on the lines of the Pennsylvania Railroad.

Heat Treating Locomotive Axles

In the plant of the St. Louis Forgings Company located in East St. Louis, Ill., is a large gas-fired furnace used for heat treating locomotive axles and forgings. By the use of gas internal strains ordinarily produced in forging are removed from the forgings in this furnace so that the finished product will be homogeneous in internal structure and ready to withstand the service to which it is going to be put. We are indebted to our esteemed contemporary, *Industrial Gas*, for the information in



Heat Treating Furnace for Annealing Forged Locomotive Axles

regard to the installation. The material to be heated is loaded on a car as shown in the illustration, which, in turn, is pulled into the furnace by means of an electrically-operated cable. The car forms the hearth of the furnace and the door rests on the top of the car, thus sealing the furnace. Along the sides of the car are sand seals which prevent heat loss at these points.

The furnace is 20 feet long and 10 feet wide inside and is 4 feet from the top of the car to the rise of the arch. Along each side and firing tangentially to the arch are 13 surface combustion high pressure burners. The flue outlets are located on a level with the top of the car and terminate at the upper end of the side walls. This form of firing has given excellent results and provides for a criss-cross action of the gases within the furnace.

A maximum burning capacity of 10,000 cubic feet of 565 B.t.u. coke oven gas has been provided for and the furnace has a normal capacity of 50,000 pounds of forgings per charge. The charge is raised to a temperature of about 1500 deg. Fahr., and accurately measured by eight thermocouples distributed equally around the furnace, whose temperatures are automatically recorded on a Leeds & Northrup recording electric pyrometer.

The furnace has been operating on gas since May, 1925, and during that time has proved to be a very dependable unit. Previous to this time it was operated on oil and then revamped to burn gas. This is supplied to the plant at six inches pressure and is metered at this pressure through three Number 4 Emco meters. From this point the gas is compressed to 12 pounds per square inch in an Ingersoll-Rand compressor and thence to the receiver tank from where it is fed to the burners.

The quality of each anneal from this furnace is given a severe test under the action of a large drop-weight testing machine.

Pacific Railway Club Proceedings

High Steam Pressures and Furnace Conditions in Oil Burning Locomotives are Discussed at December Meeting

Advancement and Advantages of High Boiler Pressures

By Wm. G. Tawse, The Superheater Company

When boilers for the generation of steam for power purposes were of the most simple form, so constructed because material and manufacturing methods had not been developed to a point where greater complication could be permitted, and thus enable higher pressures to be used. For the same reason, prime movers were capable of utilizing with safety only very low steam pressure, thus the engineer was of necessity, limited and obliged to labor under the handicap of the extravagant use of fuel and water together with low power output. Continued research and experiments produced stronger and more durable materials and better shop methods, and with these as stepping stones, steam pressures were increased and the end is not in sight.

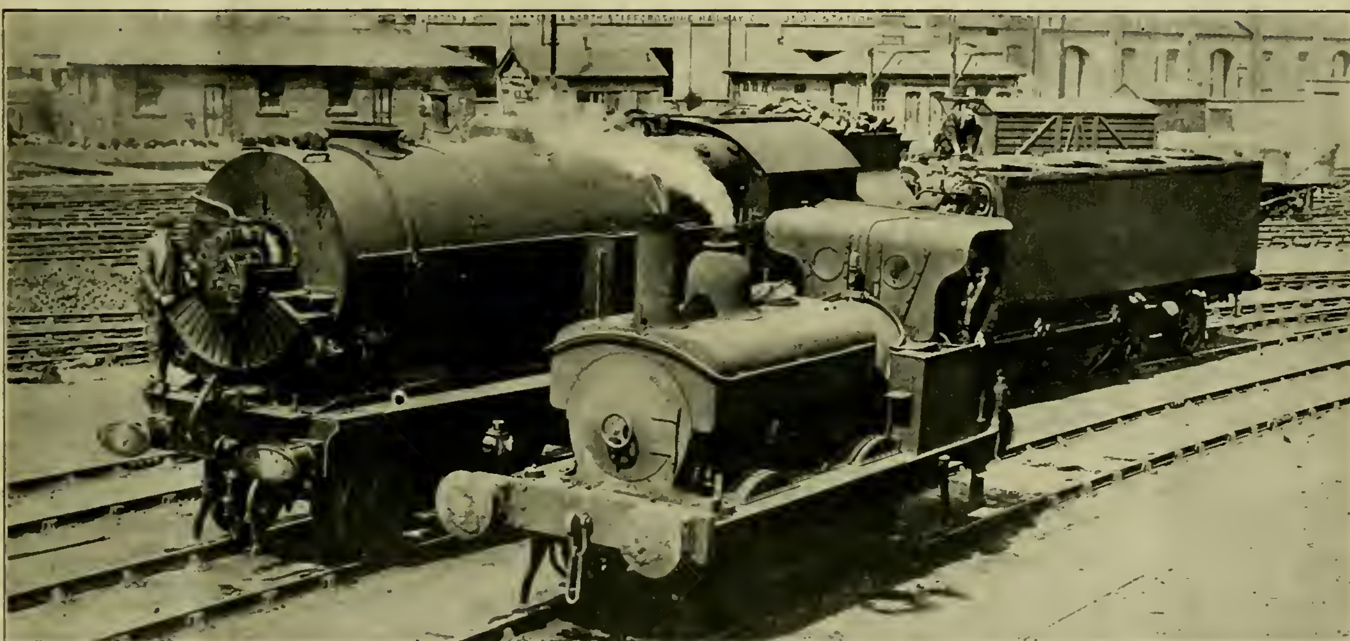
In the last ten years rapid progress has been made in the development and utilization of much higher steam pressure than had been considered. Pressures of 350, 400 and 500 pounds per square inch are in every day use, in many plants, with every known type of engine. Instances of successful practical use of pressures of 800 and 1,200 pounds can be cited, and still higher pressures per square inch are in the experimental stage, and it is reasonable to expect that practical pressures will be increased in the near future. There is a reason for increased pressures and that is the demand for more power in less space at less cost. The advantages of high steam pressures may be classified under two heads:

1. Thermo-dynamical.
2. Physical or mechanical.

The former enables more heat units per pound of steam to be delivered to and converted into work by the prime mover—whether reciprocating engine or turbine. If steam is expanded to a pre-determined release or exhaust pressure an increase in admission pressure will reduce the total heat units in the steam at release and exhaust. Of course, an increase in the ratio of expansion is necessary to accomplish this. An example of the above may be illustrated by the following:

	Pressure	Quality	Volume	Heat
Admission	205 lbs.	260 deg. S.H.	2.92 cu. ft.	1,346 B.t.u.
Release	45 lbs.	66 deg. S.H.	7.92 cu. ft.	1,212 B.t.u.
Exhaust	10 lbs.	22 deg. S.H.	....	1,171 B.t.u.

Energy converted into work=1,346=1,171=175 B.t.u.
Number of expansion=7.91=2.7
2.92



Ljungstrum Steam Turbine Locomotive on the London, Midland & Scottish Railway Shown With a Small Switch Engine

	Pressure	Quality	Volume	Heat
Admission	400 lbs.	205 deg. S.H.	1.55 cu. ft.	1,330 B.t.u.
Release	45 lbs.	98% dry	7.03 cu. ft.	1,157 B.t.u.
Exhaust	10 lbs.	94¾% dry	....	1,110 B.t.u.

Energy converted into work=1,330=1,110=220 B.t.u.
Number of expansions=7.03=4.53
1.55

Much attention has been attracted to the steam locomotive during the past few years because of marked strides which have been made in its development within that period. After an era of development which was characterized by the addition of economy and capacity—increasing devices to locomotives, the basic design of which had been little changed for many years, notable improvements in the design of the locomotive itself, have made their appearance. The result has been that the most modern locomotives have high horse power capacity in relation to size and weight. Such locomotives are capable of producing ton miles much faster than locomotives of former years with marked decreases in fuel required per thousand gross ton miles.

Naturally, we are most interested in the locomotive and in it we find perhaps the most pronounced illustration of concentrated power. A device that has reached the last measurable fraction of its growth in all dimensions and characteristics but one. Its length, height, width and weight have reached the clearance lines established by adjacent stationary objects and by the strength of the supporting rails and bridges. Its operating personnel cannot be increased, yet it is expected to meet the demands for increased power, greater drawbar pull at higher sustained speeds on less fuel, and in but one way can this be attained—higher steam pressures and temperatures.

Already the trend of design of boilers and pressure parts is well on its way toward this destination. The flat stayed surfaces are being replaced by drums or cylinders and tubes, thus permitting the use of higher pressures with less weight and greater safety and, it is claimed, better heat absorption from gases of combustion by the boiler water. Other parts of the locomotive affected by high pressure and temperature are being arranged to accommodate same. The day of the old slide valve has passed, and it is entirely possible that the piston valve of the present time will be replaced by those of poppet type, thereby obtaining decreased clearance, less leakage, less weight and reduced friction. Compounding either 2, 3 and 4 cylinders are being employed to secure full advantage of higher pressures. This produces a more uniform turning moment at the drivers with its inherent beneficial effect. Thus far only the reciprocating engine has been mentioned, but in several foreign countries, favorable consideration is being given to the turbine in connection with high pressure boilers, and a number are in daily service with satisfactory results. It may not be out of place to mention a few of the salient features of some of the high pressure boilers.

Reciprocating

The Swiss locomotive and the Machine Works of Winterthur, Switzerland, is building a reciprocating locomotive to operate at 850 pounds pressure. Details, however, are not available.

The Berliner Machine Works, Berlin, Germany, are developing a 2,500 horsepower locomotive on the Loeffler System. The combustion chamber is surrounded by tubes through which saturated steam at 1,450 pounds is circulated at high velocity by means of a pump and the resulting column of highly superheated steam is divided —part returning to the generating drum, for the purpose of producing additional steam and the remainder is used directly in the high pressure cylinder. Exhaust from this cylinder is discharged into a receiver at a pressure somewhat in excess of 250 pounds per square inch. From this receiver, the steam is re-superheated and is passed to the low pressure cylinders. A fuel saving of 45 per cent is claimed.

The Schmidt-Henschel locomotive, built by Henschel and Son, Cassel, Germany, is a 3-cylinder compound and develops about 2,500 H.P. The steam may be said to operate in three stages:

Generating stage of 1,100 lbs. per sq. in.
High pressure stage of 850 lbs. per sq. in.
Low pressure stage of 200 lbs. per sq. in.

The generating steam is confined to tubes and drums in the vicinity of the firebox. This steam is produced from distilled water and does not pass out of the space provided for it, but is circulated through water in another drum by means of coiled tubes and thus, generates steam in this drum at a pressure of 850 pounds. The latter steam is superheated in the usual manner and is used in the high pressure cylinder located between the frames. From here the exhaust passes directly to the two low pressure cylinders. An ordinary low pressure boiler supplies steam at 200 pounds pressure and also acts as feed water heater. This low pressure steam is mixed with the exhaust from the high pressure cylinder and passes with it to the low pressure cylinders. The resulting temperature of this mixture is over 600 degrees Fahrenheit. Trials have shown an increase in economy of at least 25 per cent over superheater locomotives of ordinary pressures.

Henschel also is building a turbo-reciprocating locomotive, the details of which have not been made public. However, the locomotive is similar to the usual type while the turbine and condenser are mounted on the tender. Exhaust steam from the cylinders is used to operate the turbine.

Turbine Locomotives

In 1822 Ljungstrom built the first turbine locomotive of importance. This was tested in service by the Swedish State Railways and later developments of the turbine locomotive brought out by the same firm are based on these tests.

Nydquist and Holm, licensees under Ljungstrom in 1826 delivered a 1750 horse power turbo-locomotive to the Argentine State Railways. This locomotive has been in use more than a year and is reported to be giving excellent service. The same firm recently completed another turbo-locomotive for the Swedish Railways which is in regular passenger service.

Beyer-Peacock and Company, Ltd., have built a 2000 H.P. Ljungstrom turbine locomotive for the London, Midland and Scottish Railway which now is in the regular express service between Manchester and Derby.

The Krupp Works of Germany have built a 2800 H.P. turbo-locomotive using the Zoelly type turbine. Late reports are to the effect that the performance of this locomotive is up to its guarantees and that in acceleration and tractive effort at starting it exceeds that of a reciprocating engine of a similar size.

J. A. Maffei of Munich, late in 1926, completed a 2500 H.P. turbo-locomotive for the German State Railway. The turbine of the Zoelly type is provided with reduction gearing and the shaft of the latter is connected to the driving wheels by means of side rods. The condenser and auxiliary equipment are located on the tender. Not all of the above mentioned turbo-locomotives operate at the exceedingly high pressures but the general trend is toward that end. It will be noted that while the horse power of these locomotives is much less than that of the modern American locomotive, the builders in many cases took full advantage of the economy to be secured by the use of high steam pressures. To date, the highest steam pressure used on a locomotive in the United States is 400 pounds. This is on the "John B. Jervis," built by the Delaware and Hudson Company. The "Horatio Allen," owned by the same company operates at 350 pounds as does the No. 60000" built by the Baldwin Locomotive Works.

At the present, the American Locomotive designer is content to operate his equipment at very moderate pressures and obtain economies by other means. By this is meant improved combustion and better heat absorption by the use of large grate area and firebox volume. Another development which may be credited to the United States, is the "Type E" or small tube superheater. Among the improved features of this device are:

Increased evaporating surface.
Increased gas area through boiler.
Increased fire-box volume and surface.
Increased superheating surface.
Increased steam area through superheater.

These coupled with the fact that but a single pair of tubes is placed in a boiler flue and that both boiler flue and superheater tube are of small diameter, enable better heat transfer to be obtained with an increase in over all thermal efficiency of the boiler. Inasmuch as the boiler flues are of smaller diameter than when the type "A" superheater is used the same amount of tube heating surface may be provided with a shorter length of tube. Thus, provision is automatically made for a larger fire-box with the advantages above mentioned. Comparative tests in road service have proved conclusively that for locomotives of similar type and size, the one equipped with the type "E" Superheater developed much more horse power and sustained draw bar pull—particularly at high speeds.

It is inconceivable that the American Engineer will remain long behind those of other countries in the adoption of any practice that will produce greater economies, and very likely the near future will see the universal use of steam pressures in excess of any now in common use. These will be obtained by water tube boilers and small tube superheaters.

One of the problems that will be well considered, so far as efficiency is concerned, will be the successful type of locomotive which will fulfill the operating department demand for equal or better service ability as measured by that of the conventional designs. The designing and mechanical engineers of this country will determine if the situation in this country is favorable to any quick departure from the conventional type of locomotive boiler, and will be guided by experimentation that has demonstrated superiority in serviceability or efficiency.

Furnace Conditions in Oil Burning Locomotives

By Guy M. Bean, American Arch Company

In going over the history of the application and use of liquid fuel in locomotive furnaces leaves an outstanding impression, if a broad view of the subject is taken, that there has been but little real development or change in the art. Surely the present furnace and its attendant apparatus are little different from those original installations of many years ago. The improvements have been confined to details of design rather than to any radical departure from the original general arrangement. This fact coupled with the certainty that a modern oil burning locomotive, efficiently maintained and practically operated will give such high boiler efficiencies that it leaves one in doubt as to whether there is much to be expected over and above these efficiencies by changes in the furnace arrangement or its auxiliary devices.

Motive power officials have consistently faced the possibility and in many cases the actuality of having to change their oil burning locomotives over to the use of coal. This, together with the preponderance of coal burner power has been conducive to a locomotive furnace designed for the use of coal rather than oil. The locomotive furnace has never been considered as ideal for the use of oil as fuel and the practical success with which it is used is a worthy commentary on the resourcefulness of those responsible for its adaptation.

A study of the conditions in an oil burning locomotive furnace is extremely interesting, not from the fact that anything really remarkable in furnace performance has resulted through its years of use but because it offers problems not met with in the use of other fuels. For that reason it seems advisable to give a few moments consideration to the principles of combustion of fuel oil as compared with other or so-called solid fuels so as to allow us to appreciate what is required in a furnace designed for the proper handling of liquid fuel.

It is well known that it is possible to burn certain fuels, such as charcoal and coke, in furnaces of comparatively limited volume and to obtain a very high degree of combustion. This is due to the fuel being solid even at very high temperatures and smoke from such fuels is very light, and the solid particles contained are very probably only ash, but even though of partly consumed carbon they are very small. This solidity will permit no carbon to leave the fuel bed except as a part of CO or CO_2 and these gases being colorless there will be no smoke or soot. It is due to the fact that charcoal is capable of burning to CO instead of completely to CO_2 that it cannot be classed as a perfect fuel. In this it fails to be possible to burn either charcoal or coke in a space of its own volume. In an attempt to prevent this formation of CO a large volume of air must be forced through the bed of coals but even this will not prevent all of the carbon leaving the furnace unconsumed. Therefore, after the gases leave the fuel bed there must be still further diffusion to bring the CO into contact with free oxygen to convert it to CO_2. This, however, must be done before the gas temperature has cooled below the point of ignition and as this diffusion requires time it will be readily seen that a fuel as nearly perfect as charcoal or coke requires considerable furnace volume to insure perfect combustion and for the more volatile fuels such as bituminous coal· commonly used as locomotive fuel the need for furnace volume of ample dimensions is recognized.

Before going further into detail in connection with the practical conditions in the furnace of an oil burning locomotive it was thought that considerable of flame study as pertaining to furnaces operating in the higher temperature ranges might be of value.

The length of flame from burning any hydrocarbon is largely dependent on the intensity of combustion, as well as on the completeness of air admixture. A well mixed gas burning at high temperatures will result in a short flame, whereas the same gas burned in a furnace in contact with large areas of heat absorbing surface will result in very long flames. By means of suitable refractory linings properly located, combustion will be made to complete itself in relatively short distances. It does not follow, however, that because certain fuels produce flames of extreme lengths that it is necessary to supply extreme areas of refractory linings. In fact a lining of one-tenth the normal flame length may shorten the flame to less than one tenth. Once the initial temperature of a flame is reduced below a certain figure its length cannot be controlled. This is important to consider as it indicates the necessity for completing combustion before the flame can encounter the relatively cold surfaces of firebox sheets and boiler tubes.

The vibration intensity of light varies from four hundred billion oscillations per second to nearly eight hundred billion per second, therefore about one octave alone comes within range of the human eye to discern. The lower range corresponds to the extreme red of the spectrum and the higher frequency with the extreme violet. Beyond the extreme red is a long range of oscillations which manifest themselves in heat and are invisible to the eye. Beyond the extreme violet rays exist a long series of rays known as the actinic or chemical rays. These latter are the rays most active in producing chemical effects such as are employed in the sciences, in photography, etc. Chemical action produces these rays and they in turn produce chemical action. The more intense the chemical action such as the burning of carbon, the greater will be the intensity of light produced. Very high temperatures of combustion produce light that approaches a white color the more closely as the temperature rises.

The proportion of rays of any particular color in a furnace will indicate the intensity of action which is going on in the furnace. It is very difficult for the most experienced eye to discern the full action in a furnace of very high temperature largely because of the very great quantity of heat rays which accompany the chemical rays. Temperature is so closely connected with actinism that the analytical investigation of light in a furnace will give a fair insight into its conditions of temperature. By the use of transparent glasses of suitable composition and color light may be analyzed in a manner that will greatly assist in arriving at sound conclusions and practices as related to combustion matters. A ruby colored glass will cut off the rays of light of higher vibration than ruby color, only the lower range of the spectrum being visible through such a glass. A violet colored glass, on the other hand will intercept all the less active rays and the most brilliant furnace interiors rendered visible, being colored a peculiar lavender grey which marks the ultra-violet end of the spectrum. The more perfect the combustion, the larger will be the proportion of violet light emitted by the flames.

In a well designed furnace, the whole interior surface of which is brilliantly incandescent, light radiates from every portion of the area and from the flame itself, i.e., there are no non-luminous areas. In some places the mass of flame may reveal dark streaks, these being streams of burning gas, which, while incandescent, are below the violet stage. These may be traced to the point of disappearance and would probably radiate some light if the color of glass used were less violet and more blue.

In the above flame study a furnace of large refractory exposures and proper proportioning and mechanical equipment was considered but let us now consider the less perfect furnace such as that of the locomotive where the flames quickly come into contact with or within the range of high capacity heat absorbing surfaces. With the unprotected eye the flames will appear to be giving off light all the way from their source until they disappear from the furnace. Combustion appears to be fair but if these light giving flames are examined by means of a violet glass, they will be cut down to short tongues of flame projecting but little distance from their source. Even these tongues of flame give forth little illumination. Above the flame mass the gases appear to be simply colored streams of murky, soot laden gas. The violet glass has cut out all of the rays of small actinic power and low temperature, with the result that the only light rays remaining are those immediately in the high temperature zone. This method of analysis is valuable because it shows clearly the effect of premature cooling due to the influence of the heat absorbing surfaces. It shows conclusively the benefits of proper design, operation and maintenance and is a valuable aid toward these ends.

In the combustion of fuel oil where the stream spray is used for atomization, as is common to locomotive practice, we are confronted with the fact that in the process of vaporization we not only start the particles of oil on their way to the flues at a relatively high velocity but we also interpose to a marked degree a thin layer of steam jet between the air supplied for combustion and the upper stream of oil spray that the jet carries. We are thus immediately impressed with the necessity for providing means for quick mixture of air and gas within the small confines of the refractory lined channel wherein the higher rates of combustion and higher temperatures must prevail.

The first result of the finely divided particles of oil coming into the heated portion of the furnace is to separate the carbon from the hydrogen, the carbon being left as a fine dust floating in the furnace in such a manner as to be easily carried from the furnace unconsumed, to be deposited as a thin layer of insulating soot or to be discharged from the stack in the form of black smoke. If these fine particles of carbon were attached as in a bed of hot coals a supply of air could easily complete their combustion. With liquid fuel, therefore, diffusion must be simultaneous with ignition to bring about rapid and complete combustion.

The surface tension of oil especially in a vapor or where the particles are finely divided is such as to cause the particles to assume a spherical form of extreme rigidity and therefore expose the least possible area to the oxygen. Of primary importance then is the problem of exposing the greatest possible area of fuel to the incoming air in the heated portion of the furnace. A study of atomization and diffusion is therefore of some importance and it will readily be seen that the stretching of the surface of oil is a study of capillary action and it is not hard to determine the work necessary. Oil in bulk has little surface of exposure but when broken up into fine particles of spray form it has the combined surface of the spherical areas of minute drops formed and the work of atomization is the work of stretching this surface of exposure.

It is practical to atomize oil to a definite fineness of spray by means of a mechanical device much more economically and accurately than by means of a steam jet. In stationary furnace practice the mechanical burner is becoming more and more the accepted method of vaporization but in the locomotive field it has not the attendant advantages and the disadvantages are such that the steam jet burner has held the field against many experiments with the idea of supplanting the same. The reasons leading to the adoption of the steam burner in locomotive practice are readily understood. The burners are generally simple, easy to make, relatively easy to install and maintain. Regardless of detail design they can practically all be made to atomize oil thoroughly, although some require more steam in proportion to the oil atomized than others. Two pieces of pipe properly flattened at the end will make an excellent steam atomzing burner. It is this very simplicity with which atomization of oil can be secured that has led to a great number of designs and types of steam atomizers ranging all the way from very good to very poor.

In addition to the relative ease of manufacture and the simplicity of installation the furnace efficiencies obtained with this device in the locomotive furnace, even with excessive rates of firing, are very high, as compared with those obtained from coal. Probably the highest locomotive boiler efficiencies ever reached have been secured with the use of the simple steam jet burner. It lends itself to easy, quick control; a very necessary feature in locomotive firing. The principal objection to this type of burner is the excessive use of steam, reaching in most cases as high as 5 per cent of the total steam generated, and to the attendant increase in moisture in the flue gases.

Forcing the flat steam jet burner tends to coarsen the atomization, resulting in slower burning of the fuel due to the lessened surface of exposure as compared to its volume. This thickens the flame and makes difficult the proper admixture of air and consequent poor combustion.

In most locomotive arrangements the air is admitted to the furnace below the general path of the flame either at the front of the firepan or through the floor and sides of the pan in the vicinity of the flash wall. Where the air is largely admitted at the front of the pan there is, of necessity, an added supply admitted through the fire door to support combustion in the rear of the furnace.

The air supply is, of course, interdependent on the draft supplied by the exhaust of the engine. There is a definite relation between the vacuum created in the front end, flues and furnace as compared to the size of the air openings into the pan and furnace, that is, the volume of air supplied to support combustion is as dependent on the vacuum created as is that vacuum dependent on the size of air openings. Too large air openings tend to break the vacuum chain, slow down the flow of air into the furnace and consequently restrict the oxygen supply, reduce the velocity of gas travel and create a generally sluggish combustion condition.

Various types of damper regulatory devices have been employed throughout the entire period of use of oil as locomotive fuel but with such varying degrees of success that this matter has about settled down to where the proper proportion of air opening for maximum firing conditions is provided and the degree of exhaust variance allowed to adjust the volume of air admitted at other firing stages. It is a very difficult matter to try to get proper manual regulation of air supply on a locomotive. The writer believes that all air opening regulation, whether permanent or adjustable should be controlled at the point of entrance into the furnace, rather than at some other point, such as the entrance into the boot or hopper. The admission of air directly into the furnace through the regulative opening will give the greatest degree of immediate expansion of the air stream and the consequent assistance in diffusion and vaporization of the oil particles with which the air comes into contact.

We hear more or less about gassing and drumming of oil burning locomotives. Drumming is a series of explosions following one another in rapid succession. The explanations usually given are that of too heavy atomizer pressure or too much air. Both are correct in statement but somewhat in error when analyzed. Excessive atomizer pressure tends to concentrate the stream of oil particles and force the stream in a relatively solid jet through the incoming air currents resulting in intermittent diffusion and consequent explosions or drumming. The statement of too much air supply may mean the reverse or too large air openings, a reduction in vacuum and a slowing down of the flow of air into the furnace which permits what would otherwise be a correct atomizer pressure to be excessive and thus bring about the same intermittent diffusion described above and the consequent drumming. The writer believes that careful study will indicate that the proper mixture of air supply and oil vapor is as dependent under all higher firing rates on the velocity with which air is drawn into the furnace as it is on the actual vaporization by the burner.

It is not possible in the length of this paper to go into the details and analyze the finer points of combustion as related to the subject but the whole preceeding discussion tends to show the need for rapid diffusion of the vapor and air toward the end that complete combustion and high furnace temperatures will result in the brief time alloted and in the relatively limited furnace volume provided even in modern locomotive design. At the higher rates of firing the total volume of gas evolved in a furnace of a modern Mikado type locomotive is sufficient to fill the furnace seven times per second, or stating it otherwise, there is but one-seventh of a second allowed for the combustion of each gas particle. The gases are at the same time travelling from the burner to flues at rates approximating 150 miles per hour. The large volumes of gases evolved, the amount of heat generated by their burning but emphasize the need for ample furnace volume and the careful proportioning of all equipment concerned in this operation.

The very fact that it is possible to get very high furnace efficiencies in an oil burning locomotive furnace when properly designed, maintained and operated, coupled with the fact that but slight irregularities, such as poor burners, air leaks into the furnace and improper drafting can seriously lower these possible efficiencies, should but impress us with the necessity for careful supervision and maintenance.

As stated early in this paper it does not seem possible that any radical changes in oil burner equipment for locomotives would bring about any marked increase in their present possible efficiency, however it is believed that a great deal can be done to make these possible efficiencies more nearly an every day reality than they are generally believed to be. It is believed that a more consistent testing of burners, more extensive use of superheated steam for atomizing, more reliable means of judging temperatures of oil so that consistently higher fuel oil temperatures may be used, will do a great deal to raise the every day average furnace performance.

High furnace efficiencies and black smoke most certainly do not go together and when a full realization is had of the necessity for mantenance of the highest degree of flame radiance in order that the full benefit may be had of the ideally located heat absorbing surfaces of a locomotive firebox it will be seen that everything possible should be done to create a condition where quick, complete combustion may be had at all times.

It should be always remembered that high temperatures are the result of complete combustion and not that complete combustion is the result of high temperatures.

Pennsylvania to Retire All Wooden Passenger Equipment

The Pennsylvania Railroad, which has ordered no wooden passenger cars since 1907, has decided to purchase sufficient additional all-steel passenger equipment this year to eliminate wooden cars from all regular steam passenger trains over the entire system and also from its seashore excursion trains. The directors have authorized the necessary appropriations, which will be between $20,000,000 and $21,000,000.

The company has ordered 300 70-foot passenger coaches, 210 60-foot baggage cars, and 20 combined passenger and baggage cars for delivery in 1928. Of the passenger coaches, 150 will be built by the Standard Steel Car Company, 88 by the Bethlehem Steel Company, 50 by the Pressed Steel Car Company and 12 at the railroad company's own works at Altoona, Pa. Of the baggage cars, 85 will be built by the St. Louis Car Company, 75 by the American Car and Foundry Company and 50 by the J. G. Brill Company. The combination passenger and baggage cars will be built by the railroad company at Altoona.

The Pennsylvania owns 4,541 cars of all-steel construction for the equipment of passenger trains, and 547 refrigerator cars, which are all-steel except the refrigerating portions. Last year it retired 559 wooden cars from service, and with the completion of its present program it will have about 200 wooden passenger cars, all of wide vestibule type, which will be used for emergency service.

Radio on C. & O. Freight Trains

Extensive experiments have been made on the James River Division of the Chesapeake & Ohio with radio apparatus for communicating between the locomotive and caboose on long freight trains, the apparatus having been installed a few weeks ago by the Westinghouse Electric & Mfg. Company. Loud speakers are used with success, though there is some fading when passing over or near steel truss bridges, and in tunnels. The route over which the tests are being made, has many curves, several bridges, and tunnels. Engine and caboose are seldom within sight of each other and it is impossible on long trains to give and receive hand or lantern signals.

Some Observations on the Metric System of Weights and Measures

By W. L. Austin

I have read the articles on the Metric System by W. E. Symons, and think their treatment of this weighty subject is very complete and accurate. There are so many efforts being made to compel by law the use of the Metric System in the United States, that I think it is time, as Mr. Symons says, for missionary work on this subject.

The subject of weights and measures has been a source of trouble and a topic of discussion throughout history, almost from the beginning. Whilst it is impossible to trace many things to their original source, in the case of weights and measures we seem to have a clue. Josephus, in speaking of Cain, says: "He also introduced a change in that way of simplicity wherein men lived before, and was the author of measures and weights: and whereas they lived innocently and generously; while they knew nothing of such arts, he changed the world into cunning and craftiness." According to the Bible, craftiness soon displayed itself too, for we read in Leviticus 19:35, "Ye shall have no unrighteousness in judgment, in measures of length, weight or quantity. Just balances and just weights shall ye have."

From that time to the present weights and measures have evolved through the centuries until now, the most used standards comprise what is known as the English system.

For some years now, repeated efforts have been made to supplant this System by the Metric System. It does not appear, however, that such a change is necessary or desirable.

The Metric System is a scheme of the French people and was adopted by them on December 10th, 1799, during the French Revolution. They had been working towards some systematic plan of measurement for nearly two centuries. Napoleon who had no faith in the new system, repealed the law in 1812. Immediately then the people after using it for 13 years, reverted to the old system of foot, yard and pound, as soon as they had the opportunity. Then again the Metric System was reimposed by law in 1837, but in a modified form. For half a century, after the Metric System had been legally established, the French did not discover its convenience. The alleged discovery of its convenience went along with the discovery that they would be punished if they did not use it.

The Metric System was legalized by Congress for the U. S. in 1866, but there has been no general desire to use it universally in the country.

For several years a Metric Bill has been before Congress intending to enforce the use of the Metric Systm as a Standard for the United States.

The advocates recommend the change in order to have uniformity throughout the world. If this were the only reason, then the English System should be adopted, for, to quote from the article on page 262 of Railway and Locomotive Engineering: "The fact is that the nearest approach to world uniformity has been achieved by non-metric England and America through natural processes, which no amount of legislation could have made possible."

Another reason given for the change is the superiority of the Metric System. But this cannot be proved. The original claim that it was based on a unit that is scientifically accurate had to be abandoned when it was discovered to be in error. It would have been more convenient and sensible, therefore, to adhere to the foot as a unit, and apply the decimal system to it if it was thought advisable.

Many advocates of the Metric System are confusing it with the Decimal System. Because a certain measure is expressed in decimals, it does not mean that it is a metric measure, although many people think so, and pro-metric advocates deliberately foster this mistake. So what merit there is in the System, is not in the unit, but in the decimal system applied to it. The decimal system did not require a change of unit, and could have been applied just as well to the existing foot unit and to better advantage than to have adopted a new arbitrary unit to replace the one so universally used, and which was the development of many generations, and therefore, a vital part of the language and literature.

The Metric unit was intended to be a scientifically accurate unit, equal to the ten-millionth part of the terrestrial quadrant. It was supposed that such was the case, as French Engineers had spent seven years in determining the exact Kilometre. But after being in use a number of years, it was discovered that the distance taken as the basis of a Metre was inaccurately measured. It was then too late to correct it, so that the Metre as a unit is just as arbitrary as the Foot.

Let us now restate briefly what the Metric System is. It is a System of Weights and Measures based on a new arbitrary unit, described as equivalent to the distance between terminal lines on the international prototype Metre, a bar of Platinum Iridium at the International Bureau of Weights and Measures near Sevres, France.

The great question is:

Should we meet and adopt the Metre,
Or should we treat it to de Feet

When we are asked to adopt the Metric System it is the System that was re-imposed by law in 1837 in a modified form. What is now called the Metric System is only a fragment of the original. France, after trying the new Metrology in its most universal application, had been compelled to renounce it for all measures of Astronomy, Geography, Navigation. The new laws also omitted integral parts of the original system, namely, those having a year of ten months, a week of ten days, and a day of ten hours, as well as a decimally divided circle, sphere and compass.

History tells us that the Departmental Authorities at Paris and elsewhere ordered the compulsory celebration of the Decades, or every tenth day in lieu of Sunday. This too was found so vexatious that it had to be abandoned in 1796. The centesimal 100th division of the right angle was also proposed at the French Revolution, but has long since been abandoned, even in France. The application of the system to the division of time was so unworkable as scarcely to tolerate even a trial.

As to the decimal division of the year, months and weeks, we read in French History as follows:

"As the Sun would not be prevailed on to favor the decimal system, the year, perforce, continues to consist of 12 months, but of thirty days each divided into three decades of days. The ancient pagan names of the days were abolished, and primordi, duodi, etc., substituted for them. The five days left at the end of the year were called the sans culottides, when from all parts of the Republic the

French people were to assemble and fraternize in Paris, for the celebration of the Fete of Liberty and Equality. The day was divided into twenty hours, and clocks and watches were adjusted accordingly."

We thus see that the Metric System of Weights and Measures has been very much abbreviated from the original plan. France found it impossible to make a complete change in the system of weights and measures. In 1906 Mr. Gaston Doumergue, Minister of Commerce and Industry informed the French Chamber by letter that "many trades continue to use the prohibited weights and measures," and this was after 112 years of effort and 70 years of compulsory law.

For over 100 years now, this matter has been discussed in the United States, and various attempts have been made to impose by law the Metric System on our Country. I find that the Metric System was opposed in Adams' time. It is interesting to note the opinion expressed by John Quincy Adams, past President of the United States in 1821 and after four years of investigation. "The substitution of an entirely new system of weights and measures instead of one long established and in general use is one of the most arduous exercises of legislative authority. There is indeed no difficulty in enacting and promulgating the law, but the difficulties in carrying it into execution are always great and often prove insuperable."

The legislator finishes by increasing the diversities which it was his intention to abolish, and by loading his statute book only with the impotence of authority and the uniformity of confusion. After this report the United States Government rejected the Metric System as unsuited to practical life.

Subsequent to Mr. Adams' time, the Metric System was legalized by Congress in 1866, but there has been no general desire to use it universally in the United States. Available good things are usually adopted very promptly, especially by the people of America, but this opportunity has been largely ignored. Mr. Bartlett, member of Congress, says: "Let me call your attention to the fact that for nearly 30 years the people of the United States have had the very rare privilege, have had the absolute right of enjoying and using this marvelous system. This to my mind is a salient and pertinent objection. This has been on our statute books since July, 1866, and since that day it has been lawful for the people of the United States to avail themselves of every principle contained in the Metric System. Have our people done so? Have they cried out that we must abandon the old Aglo-Saxon System of weights and measures and secure the priceless boon of a new Latin System? I say the very fact that they have not, should testify the denial of the passage of the law."

The United States Law has remained on the Statute Book permitting everybody to use the System. Use has been made of it, but only to such a limited extent, that its friends have concluded that the System cannot win its way to public favor on its own merits.

Since 1866 many attempts have been made by Metric enthusiasts to have compulsory legislation passed by means of innocent looking but lucky bills in Congress. A few years ago the Metric agitation once more became noticeable. After being avoided by the horse sense of the people, for so many years it is now proposed to compel the horse to drink out of a Litre.

The question is still up to the United States, so:

Shall we meet and adopt the Metre,
Or shall we kick it with our Foot?
Some say one thing, and some say t'other.
And some are much too easy to suit,
While others not looking for any cinch
Are unwilling to budge so much as an Inch.

Reasons Given for the Adoption of the Metric System

1st. A fixed unit from nature.
2nd. It is simple and logical.
3rd. It would save much time at School.
4th. It would result in fewer errors.
5th. It would save time in calculations.
6th. It would eliminate our confusion in Weights and measures.
7th. If we adopt it we will be using a universal system.
8th. It would enable us to sell goods abroad.
9th. They claim that virtually all the great manufacturing concerns of the United States favor it.
10th. They say efforts are being made in the United States and Great Britain to bring about the exclusive use of the Metric System.
11th. They say there are 100,000 petitions in favor of it already sent in.

Now to consider these points in detail:

1st. That the Metre is a fixed unit from nature.

This is not so. Scientists tell us that it is nearly one forty-millionth of the distance around the earth by way of Paris, the North and South Poles, but as I have already said this was afterwards discovered to be a mistake. It was found out too late, however, to be corrected and it is therefore simply an arbitrary length of a bar of metal carefully preserved in France.

2nd. That it is simple and logical, with only three units: the metre, litre and gramme, but the English System is also simple and even if it lacks somewhat of logic it more than compensates for it by its overwhelming convenience and common sense. Then too, it also has three units: the inch, pound and gallon. Theoretically, the Metric System indeed has three units but practically it has five: the metre, litre, gramme, inch and pound.

3rd. We are told the Metric System results in a great saving of time in school. Only as late as April 29, 1921, Mr. Philander P. Claxton, U. S. Commissioner of Education, stated at the Convention of a Teachers Association in Washington, that if we adopt the Metric System of Weights and Measures, we would save about a year's schooling which could go into other training. But those who have gone carefully into this subject find that the time consumed in the study of the entire subject of arithmetic does not greatly differ from the saving which the Metric party assures us would be saved by omitting the denominate numbers and weights and measures. In other words, the whole of the schooling time would be saved.

4th. That fewer errors are claimed for the Metric System. On this point, Mr. J. A. Wood, Architect, says: "I am as conversant with the Metric System of measures as with the English system of foot and inches and have used it for various foreign countries. In employing foreign draftsmen brought up on the Metric System and accustomed to it, I find their work contains more errors than when plans are made to the English scales. It is difficult to see why either should be more liable to error than the other unless it be the Metric by reason of using more figures or perhaps because the Metric unit itself is in error."

5th. We are assured of a great saving of time in calculations. They say that calculations in the Metric System is simply moving the decimal point but are there no cases of multiplication, division, subtraction, or squaring or cubing? If we compare a large number of drawings, we find the English system with its fractions or decimals is fully as simple and requires fewer figures than the Metric system. What useful purpose is subserved by designating a building lot of 24′ x 120′ in the form of 7.315m. x 36.-576m.?

L. D. Burlingame of the Brown & Sharpe Manufacturing Co., says: "Among foreign draftsmen who were brought up in the Metric System, none of them have been able to show us any problem in our practical work where there would be any saving by using the Metric System."

E. Sherman Gould, C. E., who was educated in the French Engineering School, says: "If we were to adopt the Metric System we would not find our work of measuring and calculating materially lessened. Long calculations would be as troublesome and as liable to error as ever." Here is a man who was educated in the Metric System and used both.

6th. We are told we would get rid of our confusion of weights and measures. But investigation has proved that nowhere in the world, except in Great Britain and her colonies, is there a country in which so little confusion of weights and measures exists as in our own. In no country where the metre is used is it universal. Its adoption adds confusion. We should simply add the metre to the others. This has been the history of France and Germany, in the former of which the Metric System has been in use over one hundred years.

7th. That we would be using a universal system. They say that the system is in universal use except in the United States, the British Empire and Russia, and that its use is sure to be universal. They say that the vast majority of the civilized nations have adopted it but the vast majority of the civilized peoples are using the English system and all who use the metric at all use both systems mixed together. Much is made of its adoption in South America, but the vital fact is that South American are not manufacturing countries. More manufacturing is done in Philadelphia than in all South America; besides whilst in these countries the Metric system is nominally adopted, in actual practice it is only slightly used and always in connection with the old system.

8th. That it would enable us to ship goods abroad. They say we must adopt it in the interest of foreign trade, but the evidence of a great number of manufacturers and importers is that the English System is no obstacle whatever to foreign business. In very rare cases only, The Baldwin Locomotive Works is asked to use the Metric System by our foreign customers and when they do, we accommodate them. This is only when we build special foreign engines. We have built hundreds of locomotives for France and Russia in which no mention was made of the metre at all. Credit conditions influence foreign trade but our system of Weights and Measures does not hamper it in the least. The vast export trade of American automobiles goes to all countries—metric and non-metric alike. None knows, asks, or cares to what system of measurements their parts are made and the same is true of steam engines, mining, agricultural and other lines of machinery.

The World Trade Club published a map of the world which purports to set forth the present Weights and Measure condition of the world. On this map Greenland, Patagonia and the Sahara Desert are set down as being Metric. Comment is unnecessary.

9th. They claim that practically all the great manufacturing concerns favor it but this is not so as is easily shown by the list of those who do not favor it.

10th. That efforts are being made in the United States and Great Britain to bring about the exclusive use of the Metric System. This is no argument in itself. There are many loyal efforts to the contrary. Efforts have been made now for a century in its favor and for good reasons they have failed. In the meantime those countries that thought they would use it exclusively have made modifications from time to time that prove it cannot be used exclusively.

11th. They say 100,000 petitions are on file with the Department of Commerce in favor of the Metric System, but how many of these petitioners have made a thorough investigation and have good reasons for their petitions. How many of them have spent four years in a thorough investigation as did John Quincy Adams, and then advise against its adoption?

Results if Metric System Is Adopted

I doubt if the Metric advocates realize what a serious thing they are advocating. The change from the English system would affect everything with which we have to do including our language. Note the following:

1st. Scales of all kinds would be either discarded or would require to be newly graduated.

2nd. All measures, both dry and liquid, would be discarded.

3rd. All gas and water meters would have to be changed to the new system of units.

4th. All scales of accurate measurements of steel or other material, including all yard sticks, two foot rules, tape measures and everything of the kind would be entirely useless.

5th. All designs for machinery, buildings, etc., would have to be made to the new units. Of these designs and their tracings and duplicate copies there are untold millions.

6th. All patterns now made to English dimensions would be at variance with the new unit and would have to be replaced.

7th. All gauges for accurate fitting of machinery would be out of date and the number of these gauges throughout the country passes conception.

8th. All recipe books would be useless if the units of measures are changed.

9th. In mechanical and scientific literature the confusion and expense would be stupendous. These books would all have to be rewritten including tables of all kinds and all the formulas and various supplementary books such as trade books, catalogues, books of rules, etc.

10th. These changes in mechanical books would lead to changes in other works such as encyclopedias, dictionaries, etc.

11th. All school books on arithmetic, mensuration, geometry, algebra, trigonometry, etc., would be made obsolete. Of these there are about forty millions in all.

The railroads have spent millions on plans to suit valuation orders of the Interstate Commerce Commission. These plans and millions of others of structures, of rights of way, etc., would be obsolete. Also, all freight tariffs would have to be revised as well as all passenger tariffs. All their platform, wagon and track scales would have to be changed. All their employees would have to be educated to the new system and yet we must remember that the present system is taking care of all requirements.

The cost to the householders of the country has been figured out at Forty-two Million Dollars or 210 Million Francs. The cost to the manufacturers would be enormous. Mr. Biggert, President of the United Engineering and Foundry Company estimates it would cost him about one million dollars. On this basis, it is bewildering to think of what the combined cost over the whole country would be. Also, all maps are now made to the English System on the inch scale and easily measured by anyone with a two foot rule. The change would be very detrimental.

A Summary of Objections to the Metric System

1st. It is based on an erroneous unit.

2nd. The Metric units, as well as their subdivisions, are unhandy, being either too large or too small.

Mr. Garrett P. Serviss, who appears to advocate the Metric System, says: "Now that the world is to be united as never before, no more essential step could be taken than the universal use of the Metric System." Then he proceeds to add: "It is true that for the small units of measurements, to which we are accustomed in everyday life, such as feet and inches, the Metric System does not offer any close equivalents. The millimetre which is less than a twenty-fifth of an inch, is too minute for ordinary utilization, while a centimetre makes too small a substitute for an inch, and a decimetre is too large a one. For the foot, the Metric System offers no real substitute and to obtain one by subdividing the metre it would be necessary to violate the fundamental principle of decimality on which the system is based." Note that Mr. Serviss first advocates the Metric System and then gives us valid objections to adopting it.

3rd. Metric units lack binary subdivisions of one-half, one-quarter, one-eighth, etc., which make for convenience and follow the natural inclination of the mind.

4th. Its adoption always increases confusion as old standards are always maintained with the new.

5th. The cost of the change would be beyond computation.

6th. Experience has proved that it is impossible to make a commercial success by the use of the Metric System alone and when adopted it must exist side by side with the English system.

7th. The advantage claimed for the Metric System of providing a decimal system fails by virtue of the enforced use of fractions.

8th. During the change, the confusion and additional labor would be appalling and as we learn from other countries the transition would last forever.

9th. Metric units of capacity are not suited to the needs of commerce.

10th. The usefulness of the Metric System is far from being the same in all branches of commerce and industry. This statement is made by Mr. Lallemand, a Frenchman who knows the Metric System.

11th. The Metric dimensions are not so easily stated nor so easily understood as is the English. Take the three units—inch, foot and yard. Anyone can grasp the various dimensions at once, as soon as stated. For instance, compare four and one-half inches. In English this is written 4½", but in French it is written either 115 millimetres, or 1 decimeter and 15 millimetres, or 10 centimetres and 15 millimetres. The difficulty is in grasping what is meant when a dimension (other than a very small one) is stated in a large number of units as small as the millimetre. It is much easier to grasp at once a dimension stated in feet and inches. In English we could express four and one-half inches by saying 72/16ths of an inch which would be comparable to the French expression of 115 millimetres, but it is more readily understood when stated as 4½".

As a further illustration of the lack of simplicity in French expression, please note that to express 91 the French have to say: Quatre vingt dix et un, or translated into English: four twenties, ten and one.

Advantages of the English System

1st. It is more natural and convenient. Its units of inch, foot, yard and mile easily express small and large dimensions as needed. These units and subdivisions of the English System are founded on convenience and they continue in use because they are convenient. It represents the evolution of human necessities. Every unit and its subdivision was born of specific requirement.

2nd. Its subdivisions are more convenient than the decimal. Ever since human beings have dwelt upon the earth, halves and quarters, and not tenths and hundredths, have been the natural bent of the human mind. Our decimal money system illustrates this in everyday life. What happens on any stock exchange? Are the prices quoted in dollars, tenths and cents? Not at all, they are in dollars, halves, quarters, eighths, etc. The decimal divisions of the dollar are ignored and the divisions produced by halving, re-halving and again halving.

A Belgian engineer, a few months ago, suggested to replace the metre as a unit by the dimension of 1200 millimetres, the argument being that this latter figure would be handier, being divisible by 2, 3, 4 and 6.

3rd. The English System requires fewer figures. Of the dimensions so often used, the inch and the millimetre, the English unit is the larger and expresses the same dimensions in fewer figures. Above four inches, the millimetre always requires at least three figures, and above about 40 inches, it requires at least four figures. This results in the average case of calculation in fewer figures with the English system.

L. D. Burlingame, of the Brown & Sharpe Company says: "We have had considerable experience with the Metric System in our dealings with foreign countries and we find the English System with its fractions or decimals is fully as simple and requires fewer figures than the Metric System. Among our foreign draftsmen who have been brought up on the Metric System, none have been able to show us in any problem of ours where there would be the least saving by using the Metric System.

4th. The English System is simpler than the Metric because experience proves that with the Metric System there is always a mixture of the old system. Even the French officials admit this confusion.

5th. Less liability to error goes without saying with fewer figures and a simpler system. As I have already stated, it is difficult to see why either system should be more liable to error than the other unless it be the Metric by reason of using more figures or can it be because the Metric unit itself is an error?

6th. At present, the English System is the overwhelming preponderating standard of the world. The nearest approach to world uniformity in manufacture and trade has been achieved by non-Metric England and America. The overwhelming preponderance of British and American foreign and domestic trade, and the dominating position held by their system of Weights and Measures in every commercial port, have secured for them a universality through natural processes which no amount of compulsory legislation could have made possible. Approximately two-thirds of the commerce of the world in manufactured products is on the basis of the English-American system of Weights and Measures.

7th. The English System has the widest range of usefulness. In a recent letter, Mr. Lallemand, than whom there is no more ardent defender of the Metric System, admits that the usefulness of the Metric System is far from being the same in all branches of Commerce and Industry.

Conclusion

Should we Meet and Adopt the Meter
Or Should We treat It To de Feet?

If the United States were starting out fresh and had to initiate a system of Weights and Measures, we might possibly consider some other than the English System, with an opportunity of considering the French or some modification of it. Then again, if the French nation were called upon at this time to adopt a system they, no doubt, would adopt something different from their present standard. They at least would change their unit which is based on incorrect calculations and they might also reconsider the decimal division and use a unit of 1200 millimetres as has already been suggested.

Should the United States Government then adopt the

Metric System as proposed in BILL H R 15420, now before Congress? It seems to me that it should not for the following reasons:

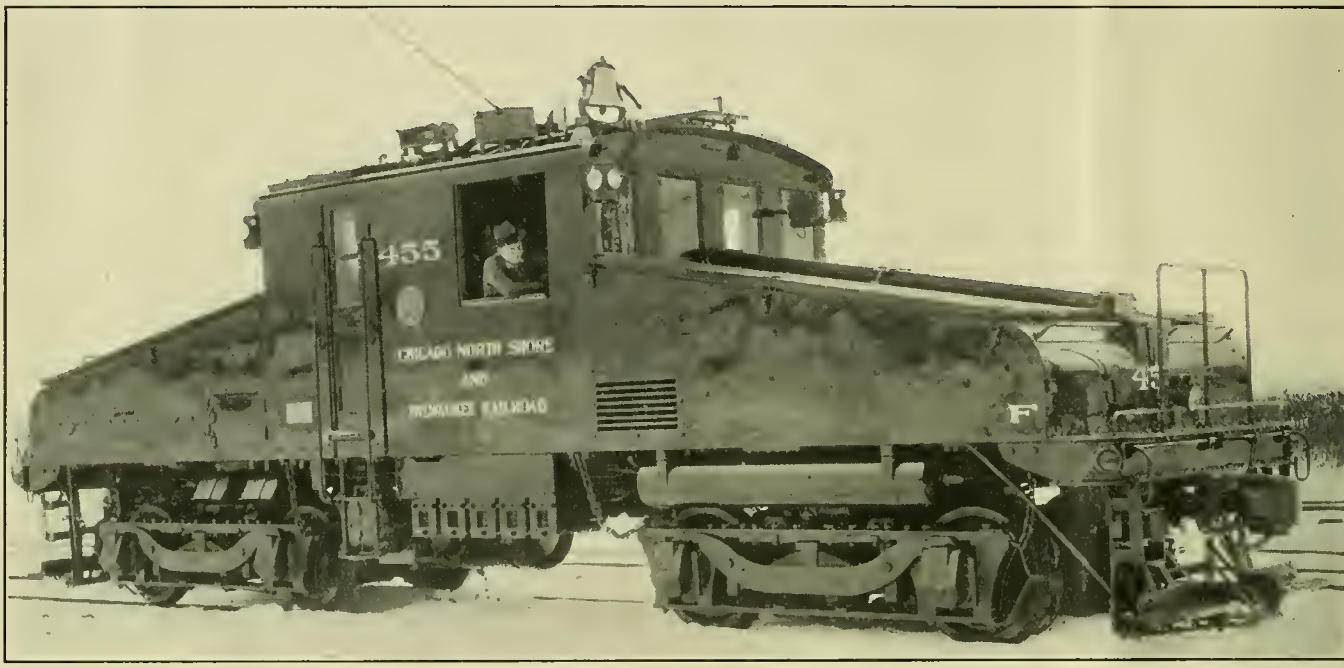
1st. Because we are asked to adopt a system whose unit has been found to be a mistake and therefore simply an arbitrary unit.

2nd. It is a system which was discarded in its own home until the people were compelled to use it or suffer penalties.

engineers, professors in engineering, and experts in all lines of engineering and manufacture.

14th. One of the strongest proofs of the superiority of the English System is that argument which is always considered final and unanswerable, namely: "The Survival of the Fittest."

It has survived all over the world and still survives. This was shown by the French nation themselves. They tried the Metric System, then when Napoleon repealed the



Electric Locomotive on the Chicago, North Shore and Milwaukee Railroad—Can Operate From Trolley or Storage Battery Power

3rd. It is not a perfect system and is capable of much improvement. Much of the original system has already been discarded and more should be.

4th. In contrast with the Metric, we have the English System which has the advantage that it is more natural and convenient, being based on the everyday needs of the people.

5th. It is more simple, using fewer figures.

6th. It is less liable to error on account of using fewer figures.

7th. It answers all requirements.

8th. It is used by the great majority of the people of the world, and they are satisfied.

9th. It is universally used in navigation sea units.

10th. It does not require penalties to compel people to use it.

11th. The adoption of the Metric System would mean a mixture of both systems. This is true of the nations that have adopted it, including the French nation as well.

12th. The Metric System is still in a state of change. Notice the German Government passed several laws in 1909, 1911 and 1913, which allow the use of the English System in certain lines of manufacture and this more than a century and a quarter after the birth of the Metric System.

The United States proposes to make its adoption complete in ten years and yet other nations are still tinkering with it after more than a century of its use.

13th. The advocates of the Metric System are in the small minority and whilst it is upheld by

The National Manufacturers of Soda Water Flavors
The Wholesale Grocers
The Retail Druggists, and others

The English system is upheld by scientists, mechanical

Metric law in 1812, they at once abandoned its use for the old system and continued to use that for about twenty-five years when a new law compelled them to use the Metric System under penalty. When freedom of choice is allowed, the survival of the fittest is sure to follow. Penalties imposed by law are not a final argument against truth. There have been too many unjust laws.

Let us then adhere to the English System, for it perfectly suits the world. It was selected by the world. It is used by the great majority of the world. It has conquered the world. It is part of the English language which Mr. Clemenceau says is spoken by two-thirds of the civilized world. Also, whatever is designed in English and made to English measures, can be measured by anyone else with any measure desired.

Finally, to quote from Mr. Henry D. Sharpe, Treasurer of Brown & Sharpe Manufacturing Company, speaking in opposition to the adoption of the Metric System, who says:

"With the present predominance of the Anglo-Saxon race in manufacture and commerce, it is felt that our system of Weights and Measures (a System convenient because worked out to meet man's practical needs, thus being well adapted to his requirements, and also having a basis of permanence through long continued use) should not be sacrificed to any theoretical system, especially when the latter lacks many important requirements of a successful system of measurement."

New Type Electric Locomotive in Operation

Two electric locomotives of a new type, designed to operate from either trolley or storage-battery power and which will automatically recharge the storage batteries when power is supplied by the trolley, have been put in service by the Chicago, North Shore and Milwaukee Railroad. Provision is made for automatically charging the battery when necessary from the trolley supply, and the locomotive is thus available for use on both trolley supply and on tracks not so equipped. The flexibility of operation enables these locomotives to switch cars into industrial plants equipped with tracks but not trolley connections. The absence of smoke, noise and noxious gases will permit running the locomotives into buildings where a steam locomotive would be objectionable.

The locomotives were built by the General Electric Company. The equipment on each includes four 200-horsepower motors and a 192-cell storage battery capable of delivering 260 kilowatt-hours on one charge. Operating on the battery, one of these locomotives can haul a 1,000-ton train at a speed of from 10 to 12 miles per hour on tangent level track or running light can attain a maximum speed of from 30 to 35 miles per hour.

A motor-generator set rated 25 kilowatts is located in the main cab of each locomotive. Its control is automatic by the use of a contact in an ampere-hour meter in the battery circuit. When the battery becomes fully charged, this contact automatically causes the motor-generator set to shut down. When the battery becomes about 15% discharged again, the set is automatically started. If, while the motor-generator set is running, the locomotive leaves the electrified line, the set will shut down and start again upon the return of trolley power, without attention from the operator.

Transfer from trolley to battery power is made automatically by means of a relay which actuates the transfer contactors. In order to restore trolley power, however, it is necessary to move the master controller to the first notch.

Each locomotive has a one-hour rating in tractive effort of 22,000 pounds at 14 miles per hour, and a continuous rating of 17,000 pounds at 15 miles per hour when operating from a 600-volt trolley. The principal data are as follows:

Weights

Electrical Equipment ..	68,000 lbs.
Air Brake & Compressor	5,000 lbs.
Mechanical Portion ..	67,000 lbs.
Total	140,000 lbs.
all on drivers	
Per Driving Axle	35,000 lbs.

Minimum radius of curvature ÷ 50 ft. loco. alone

Maximum speed—40 M. P. H.

Dimensions

Height over cab..	12 ft. 1 in.
Width of main cab	9 ft. 8 in.
Length of main cab	11 ft. 6 in.
Width of aux. cab	9 ft. 8 in.
Length of Aux. cab	11 ft. 6 in.
Length between knuckles	40 ft. 0 in.
Rigid wheelbase...	7 ft. 2 in.
Total wheelbase ..	28 ft. 8 in.
Diam. of wheels ..	36 in.

BATTERY CHARACTERISTICS

Ampere hour capacity at 6-hour rate	680
Average volts at 6-hour rate	380
Kilowatt hour capacity at 6-hour rate	258
Maximum discharge rate in amperes	3,000
Maximum Kilowatt discharge rate	600
Approximate weight of battery, lbs.	30,000

Fire Prevention by Railways Saves Millions

The efforts of the railroads along fire prevention lines have been directed at definite sources of trouble. Effective preventive and corrective measures at recognized danger spots have enabled them to bring about tremendous savings.

The Railroad Fire Prevention Association has set the field men of its members to soliciting cooperation among owners of adjoining property and industrial plants in decreasing losses. Roadway and operating officials are instructing their men in the more careful disposal of ashes and hot cinders. They are insisting on better control over burning of rubbish and material on company property. Electrical equipment is being thoroughly inspected. The most important thing which is now being done is the closer inspection of locomotives for the purpose of preventing the emission of sparks.

Railroads Assist in Reducing Forest Fires

The roads are following a policy of complete cooperation with state and Federal wardens in reducing forest fires. District superintendents and trainmasters are curbing the careless use of fuses. Close and rigid inspection of flues, heating apparatus and appliances is demanded with the requirement of building supervisors to see that rules governing such installations be strictly adhered to. The "no smoking" rule is being more strictly enforced. Installation of metal lockers and enforcement of "good housekeeping" rules are replacing wooden equipment and haphazard waste disposal.

Savings of millions of dollars each year have been effected by the combined efforts of the Class I railroads in their general campaign for the reduction of waste through loss and damage of all kinds.

An outstanding, yet typical, example of the economies achieved by the railroads is the decrease during the period from 1920 to 1926, inclusive, in fire losses sustained by the carriers.

A total of 8,388 fires on 94 Class I roads in 1926, as compared with 7,866 on 85 Class I roads in 1925, with losses amounting to $7,268,435 and $7,397,433 respectively, were reported by the Committee on Statistics of the Railroad Fire Protection Association. Although this is an increase of 522 fires, the damage was $128,998 less.

Figures for the period 1920 to 1926 depict a marked improvement in the prevention of fires. During this period the number of roads reporting increased from 75 to 94 and the mileage reporting jumped from 194,166 to 253,278. At the same time the number of fires rose from 7,975 in 1920 to a maximum of 9,210 in 1922, and then decreased to a minimum of 7,866 in 1925.

The greatest loss occurred in 1920, amounting to $10,563,914 and the smallest in 1926 when it was $7,268,435. The average loss per mile fluctuated from $54 per mile in 1920 to $28 per mile in 1926, the lowest point in the period under study.

The remarkable progress made by the Class I roads since 1920 is attested by the fact that in 1926 the amount of all fire losses in the United States was more than $560,000,000, the highest figure ever recorded. At the same time the losses of the railroads from fire touched their lowest recent point.

Iron Horse Fair Shown in Movies by the B. & O.

The Baltimore & Ohio Railroad has started a motion picture train on a tour of its system to show pictures of the Centenary Exhibition and Pageant to employees of the company and to others who were not able to attend the Iron Horse Fair at Baltimore. It consists of two cars, a coach was converted into a motion picture theatre and a baggage car into an electric generating and heating plant. The seating capacity of the theatre car is 80 people and the car is equipped with motion picture projector and screen, Orthophonic Victrola and amplifiers. In the baggage cars are installed heating system and an electric generator supplying the electricity for lighting purposes and operating the projector and music. The four-reel set of motion pictures shows the Pageant in the sequence in which it was produced at Baltimore. The music has been selected from the available phonographic records as nearly as possible to that played by the Centenary Band or sung by the Baltimore & Ohio Glee Club during the passing of the Pageant during the Centenary Exhibition.

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A Modern American or 4-4-0 Type Locomotive

Those who recall the famous locomotive No. 999 of the New York Central and other high-speed locomotives of the period of which it was representative, will remember the degree of pride with which the 4-4-0 type of engine was accepted as the established passenger service locomotive. It was with reluctance that railway officers in America yielded to the demands of the traffic for a heavier type of engine.

First, the 4-6-0 or ten-wheeler was used, then the 2-6-2, followed by the Atlantic or 4-4-2 with increased firebox capacity. Later came the Pacific or 4-6-2 and for heavy grades the Mountain or 4-8-2 type. The two last mentioned have been gradually placed on passenger runs in this country, except on light runs or branch line services where the 4-4-0 type still holds forth, awaiting however, its final retirement to make room for motor rail cars or bus service.

The glorious days of this fine example of engineering genius is a thing of the past in this country. In England, however, we find the 4-4-0 type being perpetuated not only as originally designed, but with the added improvements of superheaters, three cylinder arrangements, etc.

Elsewhere in these pages is published a description and illustration of what on close study is about as fine an indication of modern locomotive development as may be found in any wheel arrangement and it is of the American or 4-4-0 wheel type which was virtually discarded for new construction here about 25 years ago.

We do not intend to infer that our modern passenger power is too large or heavy, but, we believe, that in some cases if railways had improved the eight wheel locomotive as our English cousins have done, its gradual retirement to the point of practical elimination would have been delayed. This would have resulted in reduced costs for repair and maintenance of both motive power and the permanent way. These items of railway operating expense advanced in leaps and bounds following the introduction of the more modern heavy engines.

Without distracting from the accomplishments of American locomotive designers, we display with some pride this latest development of Mr. H. N. Gresley, C. B. E., chief mechanical engineer of the London and North Eastern Railway, and congratulate him and hope at some later date to be able to publish the results of its operation in service.

Transportation Achievements

During the last two years a conspicuous increase has occurred in the volume of railroad freight traffic, even as compared with the high figures for the fiscal years 1924 and 1925. The ton-mileage of freight in 1925-26 was about 8 per cent greater than the year before, and 1926-27 showed a further increase of about 5½ per cent. This gain in traffic was accomplished with an insignificant addition to the number of employees, a fact indicating the continued advance in the efficiency of the railways which has been going on since the close of the war. The increase in the volume of freight traffic has, in the absence of any significant changes in freight rates, served to add to the operating revenues of the railways and to increase their net operating income. Total operating revenues in 1926-27 exceeded the record figures of the preceding year by nearly 2 per cent, and there was a slight increase also in net operating income, which was thus the highest ever reported.

The increased prosperity of the railways in the last few years has gone hand in hand with steady improvement in the services rendered to the public. The chronic car shortages of former years have been overcome. The proportion or rolling equipment in bad order, both cars and locomotives, has been greatly cut down; in this respect the fiscal year 1926-27 marked the most satisfactory situation reported for many years. The tonnage per train has been increased; the average train in 1926-27 carried 786 tons of freight as compared with 656 in 1922. More important still from the standpoint of the general public welfare, delays in the movement of traffic have been greatly reduced. The expedition of railway service has reacted favorably upon the entire economic structure. It is estimated that the rapidity of freight transportation is now from 30 to 40 per cent greater than at the close of the war.

The improvement in railway service has resulted to a great degree from the efforts of the railway companies themselves, but an important auxiliary factor has been the cooperation of shippers and receivers of merchandise. The regional advisory boards of the American Railway Association, comprising representatives of producers and distributors, have served an important purpose. The organization of the system was carried to completion last year. Through the cooperation of these boards transportation needs have been analyzed and anticipated, car requirements estimated in advance, the loading of cars made heavier, and delays in loading and unloading cut down.

The Fallacy of the Metric System

Following each succeeding article and editorial in Railway and Locomotive Engineering on the proposition to introduce the Metric System, there have been responses from various sources that constitute a unanimous endorsement of our position on this important question and confirms our belief that common sense will prevail. The small minority who wish to use the Metric System may avail themselves of it, but they will not succeed in forcing its use on the great majority who do not want it.

It is particularly noticeable and most gratifying to observe the attitude of some of our great captains of industry who have strongly endorsed the retention of our present standard English units of weights and measures as being essential to our continued economical and industrial progress.

One of the ablest locomotive designers this country has produced, a gentleman of the highest order of integrity, and who was for about a quarter of a century engaged in the design and manufacture of locomotives by one of the largest single locomotive works in the world, one that has built more than 60,000 locomotives, has prepared comments on the Metric system which we are glad to present to our readers elsewhere in this issue.

While the very able and interesting review by Mr. Austin is quite self-explanatory, there are quite a few points on which we feel disposed to call special attention.

First, the fact that the French people never have, and do not now universally use the Metric System. Only a few years ago Mr. Gaston Doumergue, French minister of commerce, not only stated that manufacturers, merchants and tradesmen practically ignored the law, and still used the old weights and measures, but that to enforce the law even now would require such drastic measures as to cause profound disturbance in many industries.

Yet, the pro-metric people continue to misrepresent the facts and claim that France is exclusively on the Metric basis. It is also equally significant that it was the result of threats of punishment at the hands of a government that caused a people to use it.

The claim of absolute scientific accuracy as the basis of the Metric system falls of its own weight when we learn that La Place and his colleagues spent seven years in getting the metre absolutely correct, as they thought, then, after using it several years discovered it was all wrong, so that the metre is just an arbitrary unit the same as the foot or pound.

Since so much has been said by the pro-metric people about world trade and the great losses we in the United States suffer on account of our failure to adopt the Metric system, it would be quite in order for these people to either come forward with some proof of these claims or hereafter remain silent on that score.

The fact is credit and competitive price conditions control foreign trade, and the Metric system has so near nothing to do with it, that in order to make this claim the truth must of necessity be stretched to the breaking point. We have here the statement of a man who has been engaged in the design and manufacture of locomotives for one of the largest locomotive works in the world, that has enjoyed a good foreign business, building many hundreds of locomotives for France and Russia in which no mention was made of the Metre at all. A careful study of Mr. Austin's treatment of this most important subject should, we believe, convince any who may be in doubt as to the unquestioned superiority of our standard English units of weights and measures.

We believe that great loss of time, stupendous unnecessary expense and endless confusion would result from any attempt to enforce the provisions of the pending bill now before the House if it should be enacted into Law.

Home Study or Correspondence School Training

For more than a third of a century home study through correspondence schools has been meeting the real test of education in the dual capacity of enabling ambitious people to get a better living, and in setting before them higher standards of life.

Since the introduction of the home study method the attitude of industry has undergone a decided change. When approximately two million ambitious men and women enroll for home study courses every year the force of such training will leave its mark upon business and industry quite as surely as it will upon the individual lives of thousands who increase their efficiency and enrich their lives in this way.

Before the advent of the home study method success for the average man was problematic. Anything beyond a mere living was practically out of the question for the wage earner who, through lack of means, misguided judgment, or force of necessity had been deprived of the benefits of an education. Lack of early training is no longer a fatal handicap. Home study has removed that barrier which was once almost insurmountable, so that today any man with a sufficient urge to get out of the rut, or away from the blind alley job in which he finds himself, may do so if he wishes. The correspondence school offers the solution to his problem.

Home study is the medium by which he may bring recognition and greater accomplishment within his grasp. This method is by far the most satisfactory one yet devised for the great group of people who must work for a living or contribute to the living of others.

The value of training depends on its application. Is home study practical? Go into almost any business organization, any bank, any commercial house, any shop, mill, or factory in America today and ask the question of the officers in charge, or of the workers. A surprisingly large number of them will confess that their own success in life is due in a great measure to the preparation they secured through spare time study in the quiet of their own homes.

Put the question before the tribunal of the American public—or the world public for that matter, and you will have an affirmative declaration concerning the value of spare time training.

The first question asked by the heads of business and industry today is not "Who are you?" but "What do you know and what can you do?" Even in the industries where highly specialized operations are in effect there is a constant searching of the ranks for men who are qualified to step out of the purely mechanical jobs and into positions requiring intelligent, creative effort. There is no saturation point for intelligence. Not every man in an organization can be a superintendent or an official, but when every man in a plant has a better knowledge of his own particular work and a clearer conception of his company's policies, and a more thorough knowledge of the product it turns out, there you will find a plant in which labor turnover approaches the zero point and breakage, waste, and slip-shod work are negligible items in the overhead.

Belgian Railways Show First Profits

So successful has been the first year of Belgium's experiment with quasi-private instead of government ownership of the railroads, into which the country was forced by the financial panic of a year ago, that the post office, telephone and telegraph system is destined soon to be taken out of the ineffectual hands of the state, according to a copyrighted dispatch to the *Chicago Tribune*.

"The railway system," it is explained, "which potentially is a gold mine, yielded a mere 50,000,000 francs (about $1,400,000) last year, although it never showed a profit before. With the socialists out of the cabinet and a member of the Liberal party as head of the department, it is expected that M. Franqui, veritable dictator of the country's financial policy, will seize the opportunity to give the theory of public ownership another body blow by making the system yield real money through an autonomous company.

"Public opinion actually is awed at the success of the railway experiment and is considered ripe for the transfer, which was impossible even fifteen months ago.

"It was M. Franqui who, being a realist in finance and scornful of state ownership of anything, contrived the ingenious transfer of the railroads from the lackadaisical bureaucratic management under the thumb of parliamentary demagogues to a hard-headed commercial basis.

"Under the old bureaucratic management six trains ran every day on every line in Belgium, whether any one ever rode or not. Every train had a stated number of cars, often empty. Representatives in parliament would get their localities depots with full forces. Now the number of trains, cars, and depots depends on the traffic. The so-called 'late hours,' representing delays, have been cut to a third. The equipment is the same as before."

Heavy Locomotives of the Smaller Railways

By ARTHUR CURRAN

The response of the big railway systems to any move in the direction of larger and more efficient locomotives may be forecast without trouble, since it is certain to be an emphatic affirmative.

Of some interest, however, is the attitude of the smaller lines, upon which there is no present demand for exceptionally heavy power. Just how these roads are meeting their needs may be worth some attention; especially in cases where the 4-6-0 and 2-8-0 types have been deemed sufficient, hitherto, for the requirements of passenger and freight services, respectively.

Among these smaller lines, one of the most interesting is the Bangor & Aroostook; and, through the courtesy of Mr. C. E. Fisher, I am enabled to present a photograph of a Pacific type engine built in 1927 at the Schenectady Works of the American Locomotive Company. This locomotive, No. 251, is one of several of a class which includes various features recognized as decidedly modern. Among these may be mentioned the up-to-date throttle-rig, cross-heads, trailing truck, tender trucks, and general completeness and correct arrangement of boiler mountings and accessories. The latter include devices which are familiar to all supply men, and some of which may be seen in the illustration. The cylinders are 21x28 inches, drivers 69 inches in diameter, and total engine weight, without tender, 232,000 lbs. These F engines are not, as will be seen, very large; but they represent a considerable advance over the passenger power used on the road heretofore. In summer, they will be confined to this service, and in winter they will help to handle fast freight. It will be noticed that they have "clean lines" and general "good looks."

Going from the northeast to the southeast, we find small Pacifics on a larger system: this being the Seaboard Air Line. No less a train than the "Orange Blossom Special" is handled by a class which, so far as I can discover, is not as heavy as the B. A. R. class F.

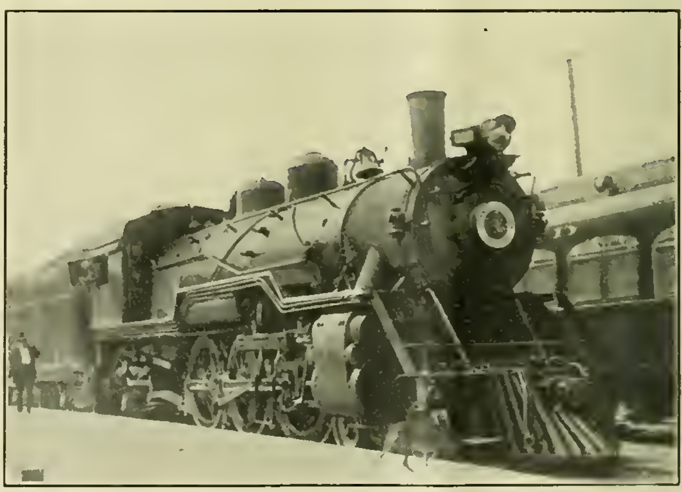
S. A. L. No. 819 is shown herewith through the courtesy of Mr. Guernsey Curran. The engine appears to belong to the class having 23x28 inch cylinders, 71 inch drivers, and a total weight, without tender, of 223,000 lbs. She would be rated as modern in all important particulars, though not a "super-locomotive," by any means.

The interest attaching to such comparatively small engines lies in their ability to render some very good service

Pacific Type Locomotive on the Bangor & Aroostook Railroad

under the conditions for which they were built. In the South, naturally enough, the climatic conditions are highly favorable to the handling of heavy loads by locomotives of moderate weight. It remains, only, to provide heavy power for such grades as require it, or for loads of unprecedented proportions. It may be remarked, at this point, that some roads in the south are using Mountain type locomotives on level divisions simply because the rail will not stand Pacifics with the same weight on drivers. In other words, the idea is merely to keep the weight per pair of drivers within a specified limit. Of course, the Mountain engines incidentally provide some margin of additional power for future increases in train weights, besides being available for "drag" freights when required for that service.

Systematic use of the Pacific type of moderate weight did not originate on any of the roads so far mentioned,



Seaboard Air Line Locomotive No. 819

however. That honor—so far as I know—belongs to the New York Central: which, as early as 1903 placed in service a class known as K, and numbering about five engines. As built by Schenectady Works, they had cylinders about 21x28 inches, 75 inch drivers, and a weight of something over 220,000 lbs. Not being large enough for the requirements of the N. Y. C., they were turned over to the Boston & Albany, which ordered further engines of the same or generally similar class. These engines had Stephenson link motion, old-style piston valves, and wooden cabs. A straight boiler, 70 inches in diameter, was used.

In due course, the B. & A. showed a preference for 22x26 inch cylinders, modern piston valves directly over the cylinders and actuated by Walschaert gear, steel cabs, and a straight boiler with a diameter at front end of 72 inches. Considerable numbers of this general design were built; though, as the weight rose by degrees to 241,000 lbs., there were several sub-classes. Orders for these engines continued up to 1913; the design remaining much the same, except that the later examples were fitted with outside steam-pipes and a newer form of trailing truck in which the rigging was modified. One of this general class, No. 535, is shown herewith. As she was going over 60 m.p.h. when I took the photograph, it was not possible to obtain an ideal "pose;" but enough of her may be seen to give a fair idea of the design. I have seen engines of this class handling as many as 13 cars.

Of course, such trains are much heavier than these engines were designed to haul; and it is not at all surprising, therefore, that new locomotives of considerably greater power are now assigned to these runs. But, that the old engines were able to handle them at all, is little short of miraculous.

The interesting part of the whole story, however, is the fact that, while all this hard work was being done on the Boston & Albany by these small Pacific type engines, similar classes were doing likewise on the Michigan Central. The magnificent Canada Southern Division is very different from the crooked and hilly B. & A., but the trainloads required some very fine locomotive work during the period under notice. Having been over the road, I know something about this; with special reference to the conditions prior to the New York Central's comprehensive new power programme.

Finally, it may be mentioned that the Big Four (C. C. C. & St. L.) used the same style of engine during this period, also. On this road, however, the loads were not, as a rule, so heavy; nor the schedules so exacting.

Naturally, the New York Central and the old "Lake Shore" had larger Pacific type engines with 79 inch drivers. These had larger boilers; and, hence, greater steaming capacity at high speed.

It is only within the past few years, however, that the little sisters of the N. Y. C. have received large power. Which makes more remarkable the exploits of the old engines right up to the recent past.

So far as the Boston & Albany is concerned, I may say that the Pacific engines built between 1907 and 1913 are still doing snappy work, and look good for plenty of further service.

Automatic Train Control

By G. E. ELLIS, Secretary, Committee on Automatic Train Control, American Railway Association

The use of automatic train control has been advocated for a number of years, and usually a collision involving serious loss of life, brings forth a multitude of newspaper comments upon this subject, without much regard being given the actual circumstances surrounding the accident.

It may have been in such a case the railroad had provided the most complete system of protection then known, and while there have been for a number of years devices proposed to prevent accidents by automatically stopping a train, their development had not been such at that time as to render their use on a large scale advisable.

This question was ably discussed in the report on automatic train control by the United States Railroad Administration Committee, and we are taking the liberty of quoting briefly from this report:

"Generally speaking, therefore, on tracks fully equipped with modern track circuit controlled block signals, train collisions can occur only as the result of one of the following causes:

"1. Failure of brakes.

"2. Failure of signals to perform their functions.

"3. Failure of employees to comply with rules or orders.

"4. Failure of employees to observe, understand or obey signal indications.

"5. Failure of signals to perform their functions is a comparatively rare occurrence. Track circuit controlled block signal systems are so designed that when any part fails the signal should display the stop indication. In some cases of failure, however, the signal indicates 'proceed' even though it should indicate 'caution' or 'stop.' Such failures, known as 'false clear' failures, contain a serious element of danger, but their infrequency makes the possibility of collisions from this cause exceedingly remote.

"Collisions due to failure of employees to comply with rules or orders are a large proportion of the total number reported and many of these could not have been prevented by an automatic train-control device.

"Automatic train-control devices may be expected to prevent only such accidents as are due to the failure of employees to observe, understand and obey signal indications. Failure to see or understand signals may be due to smoke, fog, snow, absence of the night signal indications, complexity in the scheme of indication, unfamiliarity of the engineman with the route over which the train is running, the diversion of his attention or his physical incapacity, etc. Failure to obey signal indications that are seen and understood are rare and include only those cases where enginemen in their anxiety to make time take chances, or where they use poor judgment in the interpretation of rules, which permit them to exercise some discretion. Statistics show that most of the collisions which have occurred on tracks protected by track circuit-controlled signals are due to the causes above enumerated."

Plain Stop and Speed Control

It may seem a very simple matter to provide for the automatic stopping of a train. In fact, as is evidenced by the number of patents issued, running up into the thousands, many people are apparently convinced that it is easy. It is not difficult to arrange to stop the train, particularly with the air brake now universally used, although before the development of the air brake it would have been far more difficult. The main difficulty in train control is not to stop the train but to keep it moving when it should move and not stop it unnecessarily. There is always an element of danger in stopping a train, unexpectedly, often leading to personal injuries, but, particularly in freight trains, serious damages may be done to the train by its sudden stopping, possibly resulting in blocking adjacent tracks which may lead to an accident with other trains. As traffic increases with heavy and faster trains, the problem of keeping the train moving is more serious than when traffic was much less and with lower speeds.

Automatic train control as it is commonly understood implies the use of a device by which a train is automatically stopped or its speed controlled without the aid of the engineer. It, therefore, is an emergency device intended to be effective only when those who are entrusted with the operation of the train do not take the proper action. It has been said to be a means for enforcing obedience to fixed signals. While train control is used as a general term, it may be subdivided into two main systems: the automatic stop, in which the brakes are automatically applied without reference to speed, and speed control under which the speed of the train is controlled in accordance with fixed standards depending on the local conditions existing at the time.

It has been stated that "the essential safety function of an automatic stop is to compel obedience to a stop signal." Following out this idea, the first conception of train control apparatus involved a device to stop the train by application of the air brakes after the air brake system had been developed, and in many cases a device was included to automatically shut off the steam. This latter, however, has been largely discarded, as experience has proven that the extra complication was not warranted by the benefits gained, over the application of the brakes alone.

Later studies indicated that under certain conditions an advantage would be secured by the adoption of some kind of a device which would limit the speed of the train under certain conditions, and when approaching a point at which a stop should be made, or to prevent a certain speed from being exceeded when running in an occupied block. The former has been called "preliminary" speed control and the latter "restrictive." In some installations a maximum speed has been provided which prevents the speed of the train from exceeding a certain fixed figure which is not dependent upon the occupancy of the track but upon speed alone. This may be used where curvature or other physical conditions render it desirable that the speed should be under a certain maximum.

There are two methods of securing speed control: one by the apparatus carried on the engine, and the other by apparatus installed in the track in connection with the other roadside apparatus. The former method is the one which has received the greatest development, and there is now only one installation of the second type, which is used to meet special conditions. The usual form of engine carried device is a centrifugal governor, or centrifuge as it is frequently called, attached to the locomotive wheel or axle. In all but one installation using a governor, it is attached to the outer end of forward pony truck axle. In one instance the attachment is by means of a sectional gear fitted to a tender axle; in both types the governor is driven by proper gearing and shafts. The governor itself controls the speed of the train in some cases by directly opening or closing air ports which are connected with the air brake system through the train control apparatus, or by means of circuits which control electro-pneumatic valves, that in turn put in operation the brake-setting apparatus.

The other form of speed control, that is controlled by track apparatus, usually consists of a short track section with special relays which are timed to operate in connection with the short track section. It is obvious that such an installation can have no control of the speed of the train after it leaves the location at which it is installed. It is useful in requiring the train to be at a certain speed at a given point.

Cab Signals

Cab signals are used with a number of devices and might either repeat the track indications, giving the same indications as do the roadside signals, or may be used merely to indicate the operation of the device. Usually they are visual, but audible signals in the form of a whistle or bell are also used. The cab signal indicating the condition at all times is considered practicable only with a continuous system. The other cab signals might be more specially termed "indicators," since they do not repeat the indication of the signal, except possibly when at the moment of passing. Color light signals have probably been used more than any other form for a cab indication. Recently, however, owing to development in the form of control circuits in the track, it has been possible to devise means approximately to repeat the actual signal indications in the cab as displayed on the roadside signals. This is done by means of small electric lights in a row of illuminated openings in a small box, which simulate the position of semaphore signals. Installations of this character are now being made.

An automatic train stop or control system comprises two fundamental parts or elements, that on the track and that carried on the locomotive. The two working together are designed to transmit to the locomotive the conditions existing on the track as to traffic, or, generally speaking, such conditions as would be indicated by a modern automatic block signal system. After the information is conveyed to the engineman, it may be used in two ways, either to apply the brakes, or to indicate by some kind of a cab signal, visible or audible, the conditions existing. The real problem, therefore, is to establish reliable communication between a fixed piece of apparatus on the roadside and the apparatus on a rapidly moving locomotive. This is the whole problem. There is no difficulty in providing apparatus on the track which will with a very high degree of accuracy properly indicate the condition of the track, and it is equally easy to provide apparatus on the engine which will give an indication, or apply the brakes, after this indication has been received. Involved in this problem are questions of reliability, clearance, interchangeability, proper mechanical construction and a design capable of being maintained without too great difficulty.

After the indication has been received on the engine, means must be provided for making it effective, through the air brake system, for all train control systems make use of the air brakes, and have provided no new means of stopping a train. With all types now in practical operation, this connection with the air brake system is by means of an electro-pneumatic valve, which, when the electric current is missing, will cause an application of the brakes, either by opening a special valve, venting the brake pipe, or in a few cases by directly operating the engineer's brake valve. After the automatic application has been made, it is necessary to provide means which will prevent the engineman from neutralizing the application, although he must not be prevented from producing manually a more effective application, if needed.

In some types amplifying apparatus is necessary to increase the strength of the current pick-up sufficiently to operate the electro-pneumatic valve, and in all types a relay of some character is necessary to provide for use of currents strong enough to perform their required functions.

After this apparatus has been correctly designed to produce a stop at the proper time, provision must be made to release the train after the stop has been made. This requires what is commonly known as a "reset" button, and, according to the requirements, must be so constructed that the train has been brought to a stop before the release can be effected. A provision must also be made by which the automatic apparatus may be cut out, particularly for use when trains are double-heading.

If speed control is desired, which, as now being operated, requires the speed of the train to be maintained below certain limits so long as the restriction is necessary, apparatus must be provided for this purpose; in all but one of the installations this apparatus is entirely on the locomotive.

Since the modifications of the requirements in 1924 permitting the practice of passing a stop indication without receiving a brake application, provided the engineer performs certain acts, an acknowledging lever or forestalling device has been provided. The requirements of this are that it may be operated a few seconds only before passing the stop indication point to forestall or prevent the brakes being applied.

These are the main elements of a train control or train stop system. There are many modifications or improvements.

Practical Application of Train Control

When the railroads were confronted with the order of June 13, 1922, there were only two types of train control in practical use; the mechanical trip type as used in its various forms on the Boston Elevated, New York subways, and in a few other installations, and one complete installation of the ramp type on the Chicago & Eastern Illinois Railway. There were also two short installations of other types of the ramp, sufficient to show their possibilities, but none covering a division. However, certain forms of the non-contact type, particularly one using a permanent magnet in the track, had been experimented with, and a large amount of shop and laboratory work had been done in another instance of the same type. Extensive experiments had also been carried out on the continuous induction type, but none of these had been in practical operation, although an installation of about 50 miles was early put in. The non-contact type seemed to appeal to the railroads, and some apparently felt sufficient development work had been done to justify them in taking up this type for installation, with the result that considerable field work was started at once on different examples. A large amount of field work was done on what was called the "Tapered" Speed-Control, an arrangement of roadside inductors which were so spaced as gradually to bring the speed of the train down to that desired.

In addition to the task of selecting the device itself, other problems came up, which had not perhaps been given very much consideration previous to the issuing of the order. The effect upon capacity of the railroad had to be considered, and whether, and how much, the train control device would affect the operation. The question of standardization of apparatus, so that there might be a certain degree of interchangeability, had to be considered, although wisely the roads have refrained from adopting any definite type, and thereby possibly preventing the development of other types which show promise. Coupled with the question of standardization is that of interchangeability. There are numerous cases of joint operation in the country, not alone in terminals, but for long stretches of main track, not to mention the problem of detouring trains in emergencies. So far there is not absolute interchangeability between the different devices, and apparently certain types cannot be interchangeable with other types without duplicate apparatus. Certain types of a general class, however, have been made interchangeable. The installation of a number of devices, therefore, has had the advantage of giving a practical try-out of different types, and anybody interested will be in condition after these devices have been in service to form some opinion of the merits of the different ones.

The method of installation had to be given consideration, and it was not always easy to locate the apparatus on the locomotive to the best advantage. It is not even now definitely determined what is the best place for the apparatus, whether it should be mounted on the boiler, on the tank, or whether the receiving elements should be attached to some part of the engine or to the tender truck. Different methods are being tried out and results watched, though what may be found satisfactory in one case may not be at all suitable for another road.

The location of the point at which the brake application is made varies with different installations dependent upon the operating practices of the road involved and the signal installation where one exists.

The controlling element, of course, is that sufficient braking distance must be provided from the point where the application is initiated to the point where the stop must be made. Elaborate tests were made by different roads and the braking distances used vary considerably, dependent upon the character of traffic, conditions of the roadbed and factor of safety desired. Each road has worked this problem out according to its own methods, and no standard braking distance has ever been adopted. The point of application in most of the installations is braking distance from the signal at which the stop must be made, and in practice if the blocks are not too long, this has worked out in the point of application being at the signal in the rear, which would ordinarily be giving the caution indication. If the point of application is at the signal itself, the braking distance must be provided in advance, which is equivalent to an overlap system. Both systems have arguments in their favor; the former avoids the use of an over-lap which has been generally thought to be objectionable in railroad practice and bring the train to a stop at the signal at which it should have stopped. With the overlap, however, complications are introduced into the signal system, but on the other hand, no control is exercised until it is evident that the train will not be controlled otherwise, and it is obvious that until a stop signal is closely approached it cannot be stated that the train will not be properly controlled.

Progress of Automatic Train Control

It will be interesting to note the progress which has been made in the installation of train control to meet the requirements of the Commission. According to the latest reports, the total track mileage to be installed under the two orders is 15,139 miles. There are 7,124 locomotives, including about 100 multiple unit cars on electrified sections and a few gas-electric cars. These figures vary from time to time, as minor adjustments are being made in the mileage and number of engines, but the change from month to month is very small. This mileage covers 44 divisions on first order, and 36 divisions on second order, a total of 80 divisions. All but three divisions were operated wholly or in part under some form of block signalling, and automatic signals or controlled manual block was installed on these in connection with the train control. Since train control has been installed, wayside permissive signals have been omitted on the train control territories on certain roads, so that there are now four divisions operated without permissive wayside signals, covering 691 track miles. The mileage is divided between the different classifications as follows:

	Locomotives	%	Miles	%
Intermittent Induction	3,091	43.4	6,614	43.7
Ramp Type	311	4.3	853	5.6
Permanent Magnet Type....	671	9.4	1,574	10.4
Continuous	3,051	42.9	6,098	40.3

Up to May 31, 1927, 11,556 miles were completed and in operation, and work was in progress on all of the others with about 1,500 miles of the track work complete and 750 engines equipped. From the above, it will be seen that the work is almost completed under the first and second orders.

I. C. C. Inspections

The orders relating to automatic train control stated that after installations have been made pursuant to these orders, they shall, when completed, be subject to inspection and approval of the Commission or any division thereof to which the matter may be referred. Division 1 of the Commission, consisting of three Commissioners, has had charge of train control matters. The carriers felt an inspection should be made of preliminary installations, in order that they would have some assurance that the work was proceeding along the right lines to be approved by the Commission. At first, the Commission refused to do this, but later consented to inspect installations of certain specified length and a certain number of engines. Twenty-six of these preliminary inspections were made and the conclusions of the inspection were conveyed to the executives of the carrier concerned by letter from the director of the Bureau of Signals and Train Control Devices. These usually contained several criticisms, which were taken advantage of by the railroads in completing their installations.

As soon as installations were completed, the staff of the Bureau of Signals and Train Control Devices started to make inspections of the complete installation as called for in the orders; 53 inspections have been made or are now in progress, and reports have been issued on 44. All of the installations inspected have been approved, although exceptions were made to a full approval in all but seven installations; the others had from one to seven exceptions. In addition to the exceptions, all carriers have received certain recommendations or criticisms relating to the installation.

The exceptions on the roadside relate to the maintenance of the apparatus, to the installation, under which would be classed the possibility of the track element being displaced, braking distance between track element and stop signal and other details of construction.

On the engine apparatus, the exceptions are of a similar nature, relating to the design of the apparatus, that it should provide a proper brake reduction without interference with the usual air brake apparatus, maintenance of proper relation between the engine receiver and the track element, freezing or clogging of the air valves, location of the reset or release button, proper relation of the headlight generator and the equipment of branch line and foreign engines.

The criticisms and recommendations cover a much wider field, and relate not only to the train control installation, but also the signaling. Many of the recommendations refer to the operation of the device, maintenance and inspection.

The exact relation between exceptions and recommendations is not clear, since what appear in some reports as exceptions, in later reports appear as recommendations; but at the close of the report the statement is always made that the railroad is expected promptly and concurrently to inform the Commission as to the progress made to all the above stated requirements and recommendations, which would seem to indicate that the Commission expects the requirements to be met, as well as to have the exceptions corrected.

Cost

The cost of apparatus intended to improve operation is interesting, both as to first cost and maintenance. The Commission has required the carriers to report the cost of construction, and these figures have been made public in a number of reports that have been issued. The cost of 41 installations so reported, including examples of all types, is as follows:

Automatic train control apparatus—roadside and engine, $8,479,077.

Change in signal system, $1,097,501.

New signaling, $1,668,319.

Power lines, $903,400.

Other costs, $730,579.

These 41 installations cover 6,104 miles of track.

These costs have not been analyzed and are just as they have been reported by the carriers concerned. On some roads it was necessary to make some extensive changes in signaling, which were not required to be made just at this time. In five installations at least, the cost of equipping the divisions, which did not before have signals, is included. In some cases the cost of earlier train control systems which have been installed and found unsuitable is included.

The maintenance cost is an extremely variable figure, and while this is reported monthly to the Commission, the results are such that it is quite apparent the roads are not all using the same basis. The average monthly cost for a number of divisions, including all types, except the ramp, for which figures were not available at the time this information was compiled, is $31.27 per engine; the cost per track mile is $3.00 per mile of track. These figures cover the average cost for the first three months for the current year.

Performance

The Commission requires the carriers subject to train control orders to report each month the performance record, giving the engines in service, trips made with device cut out, failures and undesirable stops due to train control and number of false clear and potential false clear train control and signal failures. The exact meaning of the term "potential" false clear failure has not been defined, but it may be assumed that it is a condition of either the engine or roadside apparatus which would result in a clear indication of the train control should the occasion have arisen which would have required a stop to be made.

The performance record on many roads is approaching the performance of the signal system as to the number of operations which occur per undesirable stop, and the number of false clear failures is very small, there being months in which neither false clear train control or signal failures are reported. In other months, there may be one or more of each reported, but an exceedingly small percentage of the number of operations. The reports as now being made are not all on the same basis, and comparisons are practically impossible, especially between the different systems.

The character of the failures naturally vary with the type of apparatus employed. Of course train control performance is affected by failures in track circuit, just as is the signal system. In the continuous system, there are occasionally failures of the special apparatus required to produce the alternating current necessary for this type, but most of the apparatus subject to failures is on the locomotive. Those engines using amplifying tubes, or ballast lamps, to regulate the voltage, were subject to considerable trouble from this source at first, but improvements are being made and causes of failure removed.

Some difficulty has been experienced from the headlight generator, since occasionally it was too small to carry both the lighting and the train control load. The use of a larger generator, and in a very few cases, duplicate generators, has overcome this trouble. The special air apparatus required on certain systems has at times been subject to failure from freezing when the valve is not properly protected, and to the grease and scale which frequently gets into the air brake system. Various failures that have occurred are being carefully investigated and improvements are being made with the result that the performance is constantly improving.

What May Be Expected From Train Control

Naturally, a method of train operation differing somewhat radically from what has been used in the past will present some difficulties or objections, but we have no record which shows these objections in a concise form. Some of the objections which were at first brought up have not so far proven to be serious. It was thought that the intermittent contact, or ramp type, would give a great deal of trouble from ice or sleet freezing to the contact edge, but that has not proven to be the case, nor has the trouble from ramps being torn out been as serious as seemed probable.

Some of the problems which were foreseen include the question of interchangeability before referred to. At the present time there have been a comparatively few cases where this has caused any serious difficulty, but possibly if train control mileage increases and more questions of joint track are encountered, particularly in terminals, this may prove to be much more serious. Tied up with interchangeability is the question of detouring trains in emergencies. This will also be of more moment if train control mileage increases. At the present time, some carriers are arranging when trains of a foreign road are detoured over their train control territory to furnish an equipped engine to handle the train, or to double-head with the original engine. Helper engines, according to the Commission's ruling, will have to be equipped to operate backwards, where they return tender first to the point of starting. This may not cause any serious difficulty, however.

Along a similar line, would be the question of operating light engines over a division to a central repair point, or over tracks used jointly by two divisions at a terminal. The requirements of the Commission also relating to engines having train control cut out on the road due to failure, may introduce some annoyance due to the "special precautions" required, and may involve some extra expense in sending out a relief engine.

In the maintenance situation, additional men may be required, particularly in the roundhouses, and the apparatus in some cases will be of a different character from that usually taken care of in such places. The operation of certain devices on the locomotive also will require a different character of maintenance than has been necessary with the headlight generator when used solely for lighting. To a certain extent this may be true with the air brakes, as an allowable leakage might, with some systems of train control, be detrimental. On the roadside, possibly an increased cost will be caused by a higher degree of maintenance in the track circuit, particularly to guard against foreign current in some systems, than has been necessary with a signal system.

Train control, of course, has been urged primarily as a preventor of accidents, and since this is the main object of its installation, perhaps a little consideration of the accident situation, particularly as it relates to train control, may be of interest before discussing other possible benefits.

As is well known, all accidents occurring upon railroads are reported to the Interstate Commerce Commission, where they result in deaths, injuries or property damage above a certain amount. These accidents are classified—

1. Train Accidents: Those directly due to the operation of trains.

2. Train Service Accidents: Those resulting in casualties to persons, but not in property damage exceeding $150 to railroad property. They are generally those of employees in attending to their duties, and include also highway crossing accidents.

3. Non-Train Accidents: Generally industrial accidents, not caused by direct operation of trains.

The major accidents are investigated by the Bureau of Safety, and a report made upon the results of the investigation.

A table is given below showing the deaths and injuries due to the different classes of accidents for the five years 1922 to 1926, inclusive. It will be noted from the table that the average annual number of deaths of non-trespassers due to collisions for the five years has been 136, or 3.24 per cent of all such deaths due to railroad operation.

Deaths of Non-Trespassers for Five Years Due to Causes as Shown

	1922	1923	1924	1925	1926	Total	Av.	Per Cent
Collision	183	126	103	121	149	682	136	3.24
Derailments	154	172	150	203	113	792	158	3.76
Other Train....	32	62	75	62	64	295	59	1.40
Train Service...	3,052	3,773	3,331	3,394	3,805	17,355	3,471	82.33
Non-Train	474	463	337	342	339	1,955	391	9.27
	3,895	4,596	3,996	4,122	4,470	21,079	....	100.00

It will be interesting to consider the record of the year 1926, in which year 26 derailments and 56 collisions were investigated by the Bureau of Safety. Of the collisions, train control would undoubtedly have prevented 24, and there are 11 which it is doubtful if train control would have saved, leaving 21, including three on electrical lines, which train control would not have prevented. There are 10 derailments which might have been prevented by train control, although it cannot be definitely stated that they would be, as it would depend upon whether the track circuit, if one existed, was interrupted or not, which cannot always be determined. A further analysis shows that 108 deaths is the maximum which might have been prevented by train control had any been in service on the territory of the accidents investigated. This 108 represents 2.43 per cent of the 4,470 deaths due to railroad operation in that year.

In 1926 there were 5,572 collisions reported to the Interstate Commerce Commission, resulting in the death of 152 persons and injuries to 2,319; 3 deaths and 8 injuries were to trespassers; 104 employees were killed and 840 injured, while there were 38 passengers killed and 1,223 injured. Other nontrespassers killed amounted to 7 and 248 injured.

We have given above the number of accidents which might have been preventable by train control. Only four of the collisions and possibly one of the derailments occurred in automatic signal territory, so that of the 35 which might have been or possibly could have been prevented by train control, there was no automatic signal installation where 31 of them occurred.

The yearly Bulletin of the Interstate Commerce Commission on Accidents gives several tabulations showing relation between deaths and injuries of employees and passengers based on the number of employees in service, or the number of thousands of passengers carried. Curves have been constructed based on these tables, which show a continual improvement in the accident situation, in that more passengers are carried per thousand killed, and there are fewer employees killed per employee in service. While there are drops in the curves showing these relations, the trend has been decidedly upward, indicating a continual increase in safety. The record for 1925 indicates that there were 5,237,000 passengers carried per passenger killed, and there were 1,118 employees in service per employee killed. At the beginning of this record, for the year ending June 30, 1889, the figures were 1,523,000 passengers and 357 employees. All this improvement was accomplished before train control was ordered. Train control, therefore, would have to be very effective in order to secure a material improvement in this record.

While the principal reason for the use of automatic train control is an attempt to prevent a certain class of accidents, certain other advantages have been claimed due to the use of it. Perhaps the principal of these is the possibility of operating without making the usual stop at an automatic signal where a speed governor is used. Some claims have been made for a certain installation, which was operated on this basis, of a remarkable saving, but the conditions were somewhat special in that case and it is not probable that the same saving could be made on every road. The saving would depend on the value given to the cost of stopping a train, which is an unknown quantity although very many different estimates under varying conditions have been made. There can be no doubt, however, that there can be a saving, and whether it would be of moment, depends entirely on the local conditions existing upon any road considering it. It also will require a change in operating rules, which has not received the test of time, in permitting a train to proceed under control of the device without making the stop at the signal. One road has been operating on its train control territory for more than a year under this method, and found it entirely satisfactory.

Another advantage may be the elimination of permissive roadside signals, resulting in saving in initial cost and the saving of the maintenance of the signals themselves. So far, this has only been proposed with the continuous system, using cab signals. Coupled with this method of operation, will also be some saving by elimination of stops, although it would be difficult to find the value for such saving.

In congested territory with the continuous system, some time may be saved owing to the fact that a more favorable condition would be immediately transmitted to the engine and the train will not have to wait until the next signal is reached.

There are undoubtedly other incidental advantages which may be developed as the use of automatic train control grows, but the total result can only be determined after some experience with accurately kept records. A few months or a year's operation will not correctly reflect the cost of maintenance and any of its advantages which may arise, nor would it show the benefits which may accrue from the use of train control.

The Future of Automatic Train Control

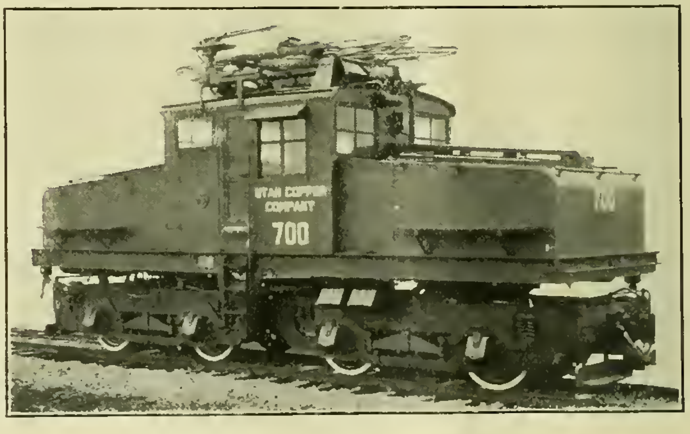
It will be useless and out of place to make any prediction as to what the future may bring in respect to automatic train control, but it seems to be reasonably certain that train control is here to stay, whether roads voluntarily extend their installations, or whether the Commission issues additional orders. At the present time, the orders issued cover 94 railroads, about one-half of those listed as Class 1 carriers, and, with possibly one or two exceptions, all with any considerable mileage have been included in one order or the other. Allowing for the exemptions and indefinite extensions of time of completion granted, there are now 44 of the larger roads with one or more divisions equipped with train control.

The total track mileage now under order of the Commission is 15,000 miles of single track, practically all of which has been installed since the issuance of the first order on June 13, 1922, a little over five years ago. As compared with the installation of automatic signals, the first of which were installed in 1883, the records indicate that that mileage of automatic signals had not been reached until more than 15 years later. The progress, therefore, seems to be commendable.

As to the final form that train control may take, no prophecy is safe. The trend has been decidedly towards the induction type, and no installations have been made of the intermittent contact type on any other road than those which had such installations at the time the order was issued. On one of those roads, an intermittent induction installation has been substituted for the earlier type. At the present time the work is about equally divided between the intermittent and the continuous, and the installation of the apparatus manufactured by two companies comprise 80 per cent of the track mileage. There is some degree of interchangeability between the different installations of each of the two types, and recent installations of the continuous type of different characteristics will tend to make the different units of that system more nearly interchangeable.

Locomotive Has Unusual Equipment

One of the largest electric locomotives in mine service, placed in operation in the summer of 1927 by the Utah Copper Company at Bingham, Utah, is especially well equipped for operating under varied conditions. The locomotive is a 75-ton, combination storage battery and trolley type, and is used for serving electric shovels and



Utah Copper Company Electric Mine Locomotive Built by the General Electric Company

for mine haulage on the various levels of the Utah Copper property.

In addition to the usual pantograph type of current collector, it is equipped with side-arm collectors, a motor-operated cable reel, and can be driven by power from its storage batteries. Where the usual overhead system of electric distribution is employed, the pantograph or side-arm collectors will be used, depending on the position of the trolley wire. Where there is no overhead wire, the locomotive can operate from the storage battery; or, by means of its cable reel, to a distance of approximately half a mile from the point of supply.

Instead of the usual practice of mounting the cable reel at one end of the locomotive, it is installed under the center of the locomotive, directly beneath the cab. An unusually large clearance is allowed between the truck framework and the body of the locomotive proper, thus making it easy to reach the motors for periodic inspection or maintenance.

A motor-generator set is installed in the cab for charging the storage battery while collecting power from trolley wires. Thus the time lost for battery charging is minimized.

The Suburban Service of the Illinois Central*

Record of First Year of Electric Operation in Chicago District

By W. M. Vandersluis, Electrical Engineer

In 1856 the Illinois Central Railroad started suburban service in Chicago by running four trains each way between down-town Chicago and Hyde Park. This service was gradually extended until 1926 when there were in regular operation on each normal week day, a total of 298 trains with service extended to Matteson on the south, to South Chicago on the South Chicago Branch, and to Blue Island on the Blue Island Branch. In the year 1925, this steam service carried a total of 24,000,000 paid passengers. Approximately 285 coaches, mostly of wood construction and with an average seating capacity of 56 persons, were used in this service. About 60 locomotives were necessary for the daily operation.

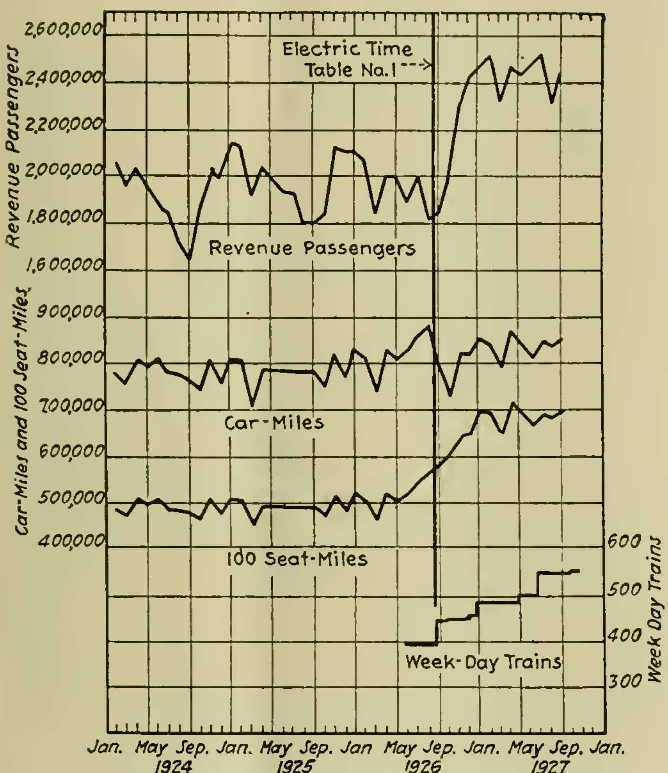


Fig. 1—Curves Showing Traffic Before and After Electric Operation

Results of Electric Operation

Electric operation for the suburban service has been agitated for years by various civic bodies, and the first formal report on feasibility and costs was made in November, 1909. This was followed by several other investigations and reports, but the railroad did not agree to the project until the passage of the so-called Lake Front Ordinance in 1919. This provided that the suburban service should be electrified by February 20, 1927.

On July 21, 1926, exactly 70 years after the first steam service was started, three electric trains were operated each way in the local service between Randolph Street and Hyde Park. The elcteric service was started seven months before the time called for in the Lake Front Ordinance. The second week 80 trains were operated each day and in the period of about five weeks the electric service was built up to a total of over 350 trains. These were all operated, of course, on the existing steam time-table, as there was still a considerable number of steam trains in the service.

The first electric time-table was put into effect on August 28, with a total of 396 revenue trains. Because of a shortage of new equipment it was still necessary to run six trains by steam, but these were confined so far as possible to those carrying shop employees. To-day, 470 revenue trains are being operated on a normal week-day. In addition there are 14 equipment trains and 72 Chicago, South Shore and South Bend trains, the latter being operated between Kensington and Randolph Street. This is a total of 556 electric trains. Electric service was put

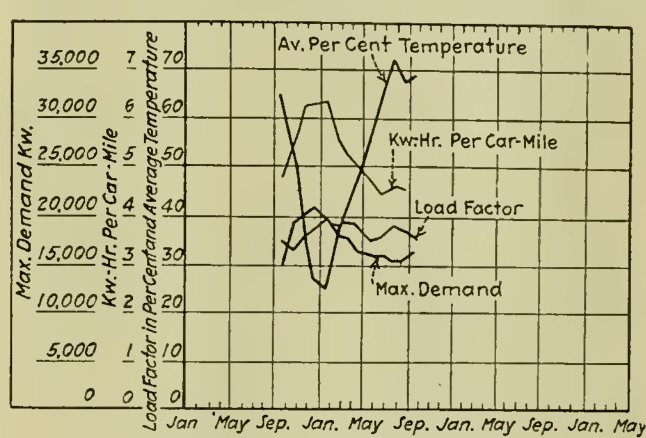


Fig. 2—Curves Showing Operating Records

into effect without any serious accidents or interruptions and has so continued during the first year.

Due to the fact that all of the motor-trailer car units are uniform in design and in operating characteristics, the preparation of time-tables and the handling of equipment at terminal points has been greatly simplified. Fig. 1 shows by months the revenue passengers carried, car-miles and seat-miles operated and the week day trains in service.

Improvement in Service

Of particular interest is the improvement in running times due to electric operation. The latest electric time-table shows decrease in running times over the old steam service of from 11 to 28 per cent for the various classes of trains, the larger percentages resulting for trains to Kensington and beyond. The decrease in over-all time results from high maximum speeds and by the use of high accelerating and braking rates. Acceleration is at the rate of 1½ mi. per hr. per sec., which is about six times as rapid as that of through passenger steam trains. Under normal operation, a train will reach a speed of 28 mi. an hr. in 20 sec. After that point, the rate of acceleration falls off but on level tangent track a train will reach a speed of 50 mi. per hr. in two minutes. With present average voltage conditions, balancing speed is about 64 mi. per hr. Although comparatively high braking rates have been accomplished on steam trains, these also have been increased so that electric trains brake at the rate of 1¾ mi. per hr. per sec.

There has been a large gain in electric operation as compared with steam operation from the standpoint of

* A paper presented to the Regional Meeting of the American Institute of Electrical Engineers.

operating a congested terminal. This improvement will become of greater importance as the service grows, inasmuch as under steam operation the limit to the number of trains physically possible to move in or out of the Randolph Street Terminal was rapidly being approached. It is readily apparent that this gain is made by the elimination of movements necessary for steam locomotives in changing ends of trains, and also in being brought from and taken to the engine terminal, since these movements must be made over the tracks serving useful train movements. The electric train requires only the normal loaded movements over these busy sections, except when brought from or taken to storage tracks at the beginning or end of rush hours.

The speed and reliability of electric service has been further enhanced by other improvements of the entire terminal. These include changes in the grades rearrangement of tracks, elimination of railroad grade crossings, installation of high platforms at all suburban stations, installment of additional interlocking plants and rebuilding of the entire automatic block system to conform to electric traction requirements, a great part of which had been completed at the time of beginning electric operation.

Fig. 3—Typical Week-Day Load Curves in Summer and Winter and Temperatures

The results obtained from the motor-trailer combination have been satisfactory to the operating officers. The elimination of all steps on the cars for regular operation which requires high platforms, the use of sliding doors, fully enclosed vestibules, tight lock couplers, automatic acceleration and electro-pneumatic braking have all tended to increased convenience of the passengers and to safety and speed of operation. The employment of a large amount of aluminum or aluminum alloys in side and roof sheets, doors, conduit and fittings has materially reduced the weight of the cars and thereby, the operating expense.

For the year ending September 1, 1927, the average cost for maintaining the cars has been about six cents per car-mile. The weight of the motor car is 70.65 tons and the trailer 44.27 tons,—an average weight per car of 57.46 tons. Delays due to electrical equipment have been very few and no radical changes in design have been found necessary. Minor changes incident to new designs have been made, but at very slight expense. Fig. 2 shows the kw.-hr. per car mile with corresponding average temperatures. Electric heating of cars is, of course, largely responsible for the variation between the different months, but changes in time-table also affect it slightly.

For the year ending September 1, 1927, the total energy supplied under the contract with the Commonwealth Edison Company was 57,274,512 kw.-hr. Of this, 92.7 per cent was for traction purposes, including heating of cars, 6.1 per cent for light and power, and 1.2 per cent for signals. Fig. 2 also shows the maximum demands by months and the variation with the temperature.

The contract provided that the railroad company guarantee a 30 per cent load factor. From Fig. 2 it will be noted that the variation in load factor is well above the guarantee. Fig. 3 shows typical summer and winter week day load curves.

The supply of energy by the power company in specified feeders to the right-of-way line of the railroad company from the seven substations has been looked upon from some quarters with misgivings. This requires that not only the conversion machinery but all protective apparatus in the railroad company's feeders be maintained by the power company. The railroad company, however, has taken over, under normal operation, the control of all traction feeders by use of its supervisory control system. So far the results obtained have been satisfactory with the power company's broad-minded policy in operating under the necessarily somewhat complicated agreement.

Discrimination of the high-speed circuit breakers has been excellent. The over-head network on a multiple track railroad, such as this installation covers, is complex due to a necessity, in case of a fault, of having a minimum amount of track out of service. Isolation of individual sections, in case of trouble, has come up to expectations with very good protection to line and equipment. Furthermore, the power supervisor controlling the traction feeders has immediate information as to opening of breakers. He is located in the office of the train dispatcher, so that by working close together, trouble from a train going from a live to a grounded dead section has been minimized. The use of wayside signals indicating a dead trolley section at points where the sectioning is outside the limits of interlocking plants has also saved burn-outs of overhead.

General Results

As indicated by Fig. 1, it is apparent that the traveling public will use a clean, fast and reliable transportation system. The off-peak business has increased materially, which, of course, is the most satisfactory business to have.

In providing the electrified service the railroad spent ten and one-half millions of dollars for new equipment, about four millions for electrical work, including overhead, switching equipment, return system and miscellaneous, and about nine and a half millions for rearrangement of old tracks, new track and station facilities and separation of grades, or a total of twenty-four millions in improvements only. An additional twenty millions of dollars was spent in the rearrangement of the terminal facilities for the whole electrification project.

Railway and Locomotive Historical Society

The Railway and Locomotive Historical Society has announced completion of its new headquarters at the Baker Library of the Harvard Business School, Boston, Mass., and that it is now open for visitors. The room assigned to the Society is decorated with over 200 framed pictures of historic locomotives and other railway scenes. It also contains a valuable collection of books dealing with railway and locomotive subjects and all railroad men and others interested in these things are invited to visit the room.

The Society has recently issued its Bulletin No. 15 which contains some highly interesting material. An article by the president of the organization, Charles E. Fisher deals with Locomotive Building at Taunton, Mass. It gives an outline of the history of the poineer locomotive builders, the Taunton Locomotive Works, and the Mason Machine Works. It also gives the history of William Mason, one of the greatest locomotive designers that America has produced. He is generally said to have been the first to bring the cylinders to a perfect level and to have introduced spreading of the truck wheels. He was also the first to apply a Walschaerts valve gear to a locomotive in America. His eight-wheel type of engine helped to established the American or 4-4-0 wheel arrangement, a popular design for many years.

William Mason introduced the conical headed staybolt for the crown sheet and made driving wheels with hollow spokes and a hollow rim, pouring in lead for a counterbalance.

Both the Taunton Locomotive Works and Mason Machine Works built locomotives for virtually all of the prominent railways of their time.

Other interesting items in the Bulletin include The Genesis of the Locomotive Truck by J. Snowden Bell, The First Locomotive in the State of Maine by Charles S. Given, Famous Locomotives Still on Exhibition by Norman Thompson, A Bury Engine in Ireland by G. W. Bishop, St. John and the Canadian Pacific Railway by Warren Anderson.

$750,000,000 for Railway Equipment and Improvement in 1928

The railways of the United States and Canada will spend approximately 750 million dollars during the current year for new equipment, and additions and improvements to their properties, according to information now available.

During the years 1920-1927 inclusive, the eight-year period since the termination of Federal control, the railways of the United States alone spent about 6 billion dollars for the improvement of their properties, an increase of 25 per cent in investment. During the last five years alone, they have expended $4,317,169,000 of new money, an average of more than 850 million dollars annually.

The following table shows these expenditures for each year since 1920:

1920	$ 653,260,000
1921	557,035,000
1922	429,273,000
1923	1,059,149,000
1924	874,743,000
1925	748,191,000
1926	885,086,000
1927 (last 3 months estimated)	750,000,000
TOTAL	$5,956,737,000

The total amount carried over into 1928 by the roads exceeded $200,000,000, exclusive of equipment ordered during the closing weeks of the year, payment for which will not be due until delivery. This sum compares with $475,000,000 carried over from 1925 to 1926, and $350,000,000—plus liberal appropriations for additions and improvements in the following early months—carried from 1926 to 1927.

950 Millions Available in 1928

The total sum available for expenditure in 1928, then, is $950,000,000. It is not to be expected that all of this will be spent this year, for some of the work will of necessity be carried over into 1929.

These figures are based upon an analysis by Elmer T. Howson, Western Editor, *Railway Age,* who also estimates that more than 300 million dollars, or about 40 per cent, of this year's expenditures will go for equipment. The indications are, Mr. Howson feels, that this figure will increase rather than diminish as the year advances.

One of the outstanding features of the 1928 budgets is the curtailment of the mileage of new lines contemplated. In 1926, there were 1,005 miles of new line built, a figure greater than in any year since 1916. Mileage in 1927 reached a total of 772, still greater than any year's total since 1917 with the single exception of 1926.

900 Miles of New Line

At present 900 miles of new line are under construction most of which will be completed during the coming year. The carrying over of this large extension mileage is directly due to adverse weather conditions encountered last spring. No extensions of such magnitude are authorized for 1928, and indications are that new lines authorized this year will not exceed half the mileage of those now under construction.

A similar though less pronounced tendency appears in the amount of second, third and fourth track construction projected.

Only a limited number of roads are contemplating extensive revision of their car and locomotive shop facilities. The work represents heavy expenditures, however, and the total is estimated at $15,000,000, while capital expenditures for tools are expected to approximate $10,000,000, this amount representing added investment above the cost of the tools replaced.

A significant factor is the large and rapidly increasing proportion of available funds that are being spent for the elimination of grade crossings. The 1928 expenditure of all roads for this purpose is expected to exceed $65,000,000. More than $75,000,000 will go for miscellaneous expenditures such as strengthening of bridges, new and improved water stations, and other improvements of like character.

Notes on Domestic Railroads

Locomotives

The Boston & Maine Railroad is said to be in the market for 20 freight and passenger locomotives.

The Toronto, Hamilton & Buffalo Railway is in the market for two 2-8-2 type locomotives.

The Seaboard Air Line has ordered 25 six-wheel switching locomotives from the Baldwin Locomotive Works.

The Red Wood Lumber Company has ordered two electric locomotives from the Westinghouse Electric & Manufacturing Company.

The Mobile & Ohio Railroad has ordered 8 six wheel switching locomotives from the American Locomotive Company.

The Great Northern Railway expects to place an order for 6 Mallet type locomotives.

The Union Pacific System is inquiring for 23 locomotives of the 4-12-2 (Union Pacific) type and 15 locomotive tenders.

The Western Lumber Company has ordered a Consolidation type locomotive from the Baldwin Locomotive Works.

The Siamese State Railways have ordered 8 three-cylinder locomotives from the Baldwin Locomotive Works.

The Sloss-Sheffield Steel & Iron Company has ordered a Consolidation type locomotive from the Baldwin Locomotive Works.

The Chesapeake & Ohio Railroad has given a contract for the repair of 12 class H-4 Mallet type locomotives, to the Newport News Shipbuilding & Dry Dock Co. The work is to be done at an approximate cost of $300,000 in the shipbuilding company's shops at Newport News.

The New York, New Haven & Hartford Railroad is beginning to receive deliveries on the locomotives of the 3-cylinder McClellan firebox Mountain type, being built at the Schenectady plant of the American Locomotive Co.

Passenger Cars

The Atchison, Topeka & Santa Fe Railway has ordered 76 miscellaneous passenger cars from the Pullman Car & Mfg. Corp.

The Union Pacific System is inquiring for 10 dining cars and 15 coaches.

The Mobile & Ohio Rairoad is inquiring for three 69-ft. steel passenger coaches and three 69-ft. steel passenger coaches with partition.

The Chicago & Alton Railroad is in the market for two 60 ft. postal cars and seven 70-ft. combination postal and baggage cars.

The Western Pacific Railway has ordered 4 cafe cars from the Pullman Car & Manufacturing Company.

The New York, Westchester & Boston Railroad has ordered ten motor passenger train cars from the Osgood Bradley Car Co.

The Chicago & Eastern Illinois Railway has ordered two combination mail and smoking cars from the Pullman Car & Mfg. Corp.

The Pennsylvania Railroad has ordered six 73-ft. gas-electric rail motor cars to be equipped with Electro-Motive Company 275 h.p. power plants.

The Chicago, Burlington & Quincy Railroad has ordered one gas-electric rail motor car from the Mack Trucks, Inc., and 25 gas-electric rail cars from the Pullman Car & Mfg. Corp.

The Pennsylvania Railroad has inquired for 690 items of passenger and baggage equipment as follows: 300 express refrigerator cars, 200 passenger coaches, 100 baggage-express cars, 45 theatrical scenery cars, 25 horse express cars and 20 passenger-baggage cars. They have ordered six double power plant, 73-ft. gas-electric rail motor cars from the J. G. Brill Co.

The New York Central Lines has given an order for the rebuilding of 33 steel underframe passenger coaches, to the American Car & Foundry Company.

The Chicago, North Shore & Milwaukee Railroad has purchased 15 motor cars and two parlor-observation cars from the Pullman Car & Mfg. Corp.

The Canadian Pacific Railway has ordered 15 palace horse cars and 5 parlor-cafe car frames from the National Steel Car Corporation and 20 first class passenger car frames from the Canadian Car & Foundry Company.

The Delaware & Hudson Company has renewed its inquiry for eight combination baggage and mail cars.

The St. Louis & San Francisco Railway is in the market for 15 baggage and mail and five baggage cars.

The Texas & Pacific Railway has ordered 3 dining cars and 5 combination baggage and express cars from the American Car & Foundry Company.

The Long Island Railroad has inquired for ten baggage cars and two baggage-mail cars.

Freight Cars

The Mobile & Ohio Railroad has ordered 250 box cars and 200 flat cars from the Mount Vernon Car Manufacturing Company, and 250 gondola cars from the General American Car Company.

The Lake Superior & Ishpeming Railroad is inquiring for 250 ore cars.

The Southern Pacific Company is inquiring for 300 box car underframes and superstructure parts.

The Lehigh & New England Railroad has given an order to the American Car & Foundry Company for making repairs to 200 hopper cars, of 50 tons capacity.

The Baltimore & Ohio Railroad is expected to come into the market for 2,000 steel car bodies and possibly 2,000 70-ton steel hopper cars.

The Bangor & Aroostook Railroad is in the market for 100 box cars.

The Chesapeake & Ohio Railroad will it is rumored inquire soon for a large number of freight cars. The total may be as much as 8,000 or 10,000.

The Chicago & Eastern Illinois Railway is inquiring for 500 automobile box cars of 40 tons capacity.

The Chicago, St. Paul, Minneapolis & Omaha Railway has ordered 250 gondolas from the Standard Steel Car Co.

The Pacific Fruit Express is about to inquire for 2,000 refrigerator cars.

The Southern Raiway System has placed orders for 4,750 freight cars distributed as follows: 2,000 hopper cars, with Standard Steel Car Co.; 1,750 automobile cars, with American Car & Foundry Co.; 250 ballast cars with Rodger Ballast Car Co.; and 750 hopper cars, with Mount Vernon Car Mfg. Co.

The H. C. Frick Coke Company has given a contract to the American Car & Foundry Company for making repairs to 137 seventy ton cars.

The Great Northern Railway has ordered eight dump cars from the Koppel-Industrial Car & Equipment Company.

The Chicago, Burlington & Quincy Railroad is inquiring for 150 ballast cars.

The Northern Pacific Railway has ordered 50 caboose car underframes from the Siems Stembel Company.

The Texas & Pacific has ordered 500 gondola cars from the Pressed Steel Car Company and 300 flat and 200 automobile cars from the American Car & Foundry Company.

The Canadian Pacific Railway has ordered 200 refrigerator cars from the National Steel Car Corporation; 300 automobile cars and 50 Hart-Otis ballast cars from the Canadian Car & Foundry Company.

The Pacific Fruit Express has ordered 600 steel underframes from the Pacific Car & Foundry Company.

The Texas & Pacific Railway has ordered 10 caboose cars from the American Car & Foundry Company.

The Fruit Growers Express is inquiring for 480 steel underframes for refrigerator cars.

The St. Louis-San Francisco Railway is inquiring for 30 air dump cars.

The Atchison, Topeka & Santa Fe Railway has ordered 100 air dump cars of 30 cu. yd. capacity from the Magor Car Corporation and 100 caboose cars from the American Car & Foundry Company.

The Chesapeake & Ohio Railway is inquiring for 500 hopper car bodies of 70 tons capacity and repairs to 500 sets of 70-ton trucks.

The Louisville & Nashville Railroad has ordered 100 ballast cars from the Rodger Ballast Car Company.

The Otis Steel Company, Cleveland, Ohio, has ordered 6 30 cu. yd. extension side dump cars, from the Clark Car Company.

The Union Pacific System contemplates buying about 500 50-ton flat cars.

The Norfolk & Western Railway will buid 250 all-steel gondola cars of 90 tons capacity at its Roanoke shops, and is inquiring for bids for rebuilding 1,000 all-steel, 57½-ton hopper cars.

The Lehigh & New England Railroad is inquiring for six caboose cars and 200 steel coal cars.

The Louisville & Nashville Railroad has ordered 1,250 gondola cars from the Pressed Steel Car Co., 200 low-side gondolas, 200 auto, 300 box and 200 stock cars from the Mt. Vernon Car & Mfg. Co.

The Maryland Slag Co. has ordered two extension side dump cars of 35 cu. yd. capacity, from the Clark Car Co.

The Metal & Thermit Corp., New York, has ordered one Class V tank car, for carrying liquid chlorine, from the General American Tank Car Corp.

The St. Louis Southwestern Railway is inquiring for six freight car underframes.

The Manila Railroad has ordered 50 flat cars from the Gregg Company, and is inquiring for 50 box cars of 30 tons capacity.

The Warner-Quinlan Co., New York, has ordered 15 insulated tank cars from the American Car & Foundry Co.

Wilson & Co., Chicago, are inquiring for 300 refrigerator cars of 40 tons capacity.

The Woodward Iron Co. is inquiring for ten steel ore cars of 60 tons capacity.

The Republic Iron & Steel Company is inquiring for 50 gondoa car bodies of 70 tons' capacity.

The Standard Oil Company of New Jersey is inquiring for 12 all steel fifty-ton box cars.

The Chicago Great Western Railway is inquiring for 55 freight car underframes.

Supply Trade Notes

Botfield Refractories Co., Philadelphia, Pa., manufacturers of Adamant fire brick cement has announced the appointment of **Ires Prosser** as Southeastern representative. Mr. Prosser's territory will embrace the entire Southeast from North Carolina to San Antonio, Texas. His headquarters will be Atlanta, Georgia.

Leeds, Tozzer & Co., Inc., New York, announce that they are equipped to design and furnish special purpose machine tools and machinery, and to represent manufacturers as sales agents. **Edward L. Leeds**, president, was recently vice-president and director of Niles, Bement Pond Co., vice president of Pratt & Whitney Co., and formerly assistant general manager and manager in Europe of the Brown Hoisting Machinery Co. of Cleveland. **Brent A. Tozzer**, vice president, was recently New York manager and sales engineer of the Niles Tool Works Co. and Pratt & Whitney Co. and formerly sales engineer and European representative of the Lodge & Shipley Machine Tool Co. of Cincinnati. Associated with the company are experienced engineers who have designed and built many special purpose machines and many machines for mass production.

S. H. Burr, formerly inspector and line material specialist of the **Graybar Electric Company**, has joined the engineering department of the **Copperweld Steel Company**, of Glassport, Pa., with headquarters at New York.

The Cohoes Rolling Mill Company, Cohoes, N. Y., has created a special railroad sales department and **P. C. Doerr**, who has been connected with the company for the past two years, after January 1 will devote all of his time to railroad sales.

Gerald F. Davis has been appointed manager of the New England Division of the **Graybar Electric Company**, to succeed **Theodore E. Burger**, resigned. Mr. Davis has been with the Western Electric and Graybar companies for nearly 20 years and goes to New England from Pittsburgh, where he was branch manager.

Charles L. Butler, representative of the **Detroit Lubricator Company**, has resigned to become manager of railroad sales for the **Goodall Rubber Company**, with headquarters at 117 North Wacker Drive, Chicago.

The Harrington Company, Philadelphia, Pa., has sold its machine tool business together with drawings, patterns, jigs, tools and fixtures, patents and good-will to the **Consolidated Machine Tool Corporation of America**, Rochester, N. Y.

J. A. Bennan, president of the **Jefferson Electric Manufacturing Co.**, has been elected president and general manager of the **Chicago Fuse Manufacturing Co.**, Chicago, Ill.

George W. McIntyre, formerly representative of the **Niles-Bement-Pond Company** has been appointed representative of **Reed-Prentice Corporation** with headquarters at 75 West Street, New York City.

The Okonite Company, Passaic, New Jersey, has purchased the insulated wire department of the **Hazard Manufacturing Company** at Wilkes-Barre, Pa., which will be operated as **The Hazard Insulated Wire Works** a division of the Okonite Company.

T. S. Carrick has been appointed general manager of the industrial department of the **American Arch Company, Inc.**, New York. He will have full charge of all matters relating to the company's furnace products.

J. S. Doyle, formerly assistant to the president of the **Continental Brake Shoe & Equipment Company**, is now assistant manager of the electric street railroad and motor bus division, general railroad department of the **Johns-Manville Corporation**, New York. This division has been created to serve the increasing requirements of this phase of transportation.

P. Baackes, vice-president and general sales agent of the **American Steel & Wire Company**, Chicago, has been elected senior vice-president. **D. A. Merriman**, assistant general sales agent, has been promoted to general manager of sales. **L. J. Gray**, assistant superintendent of mills, has been promoted to assistant to president.

A. M. Anderson has been appointed sales engineer in charge of the railway department, western territory, of the **Gould Storage Battery Company, Inc.**, with headquarters at 32 West Randolph street, Chicago.

P. C. Brooks, president of **E. T. Fairbanks & Co.**, scale manufacturing subsidiary of **Fairbanks, Morse & Co.**, and vice-president of the **Canadian Fairbanks, Morse Co., Ltd.**, has been elected vice-president of **Fairbanks, Morse & Co.**

George L. Pollock, vice-president and treasurer of the **Burnside Steel Foundry Company** since its organization, has resigned to become vice-president of the **Nugent Steel Castings Company**, Chicago.

Charles H. Leinert, president of the **Leinert Valve Company, Inc.**, 310 South Michigan avenue, Chicago, has been appointed district representative in the Chicago district, for the **Birdsboro Steel Foundry & Machine Company**, Birdsboro, Pa.

The Harrison Steel Castings Company, Attica, Ind., has acquired all of the assets and real estate of the **National Car Coupler Company** of Attica, Ind. This company will operate the plant, continuing the manufacture of miscellaneous steel castings, knuckles and couplers with the same management that the former company operated.

Items of Personal Interest

A. J. Lewis has been appointed master mechanic of the Missouri-Kansas-Texas Lines at Parsons, Kans., succeeding **J. J. Melley** resigned.

C. M. Stone has been appointed roundhouse foreman of the Southern Railway at Birmingham, Ala., succeeding **J. M. Riley**, transferred.

S. L. Landis has been appointed road foreman of engines on the Missouri Pacific Railroad at Osawatomie, Kans., where he succeeds **H. J. Wade**, who has been transferred as acting road foreman of engines at Nevada, Mo.

George Thibaut has been appointed assistant mechanical superintendent of the Erie Railroad at Meadville, Pa., where he is succeeded by T. F. Gorman.

F. Wiseman, road foreman of engines on the Michigan Central Railroad at Jackson, Mich., has been promoted to assistant master mechanic at that point.

B. H. McKarrel, car foreman of the Chicago Great Western Railway, Chicago, has been promoted to superintendent of the car department with headquarters at Oelwein, Iowa, succeeding **M. F. Covert**, who resigned.

H. A. Scandrett has been appointed president of the re-organized Chicago, Milwaukee & St. Paul Railway of the Chicago, Milwaukee, St. Paul & Pacific as it is now called. He was vice-president, valuation and commerce counsel, of the Union Pacific System.

W. E. Harmison, master mechanic of the Erie Railroad at at Port Jervis, N. Y., has been transferred in the same capacity with headquarters at Meadville, Pa.

W. C. Stenason, general air brake inspector of the Canadian Pacific Railway at Winnipeg, Man., has been promoted to master car builder of the Western lines, succeeding T. G. Armstrong, retired.

G. W. Wyman has been appointed traveling engineer on the Delaware Division of the Pennsylvania Railroad.

Don Nott has been appointed assistant master mechanic of the Chicago, Burlington & Quincy Railroad with headquarters at Galesburg, Ill.

H. Smith has been appointed master mechanic of the Canadian Pacific Railway with headquarters at London, Ont., succeeding **E. G. Bowie**.

W. E. Scripture has been appointed assistant road foreman of engines of the Fort Wayne Division of the Pennsylvania Railroad.

J. A. Griffith has been appointed general foreman of the Southern Railway at Charlotte, N. C., succeeding **E. C. Todd**, resigned.

B. C. Nicholson, general foreman on the Missouri-Kansas-Texas Lines at Oklahoma City, Okla., has been promoted and is now master mechanic at Wichita Falls, Texas, succeeding **R. A. Walker**, transferred to Muskogee, Okla.

J. H. Winfield, formerly general inspector of the Erie Railroad at Hornell, New York, has been promoted to master mechanic at Port Jervis, New York.

W. H. Edmunds has been appointed electrical engineer of the Colorado & Southern Railway with headquarters at Denver, Colo.

Obituary

Marvin Hughitt, chairman of the finance committee of the board of directors of the Chicago & North Western Railway since June, 1925, and for a period of 37 years prior to that time, president and chairman of the board, died at his home at Lake Forest, Ill., on January 6, following a stroke of paralysis. Mr. Hughitt had been actively connected with the affairs of the North Western until the day before his death and had spent 71 years in railroad service. He was born on August 9, 1837, at Genoa, N. Y., and attended the public schools at Auburn, N. Y. In 1854 Mr. Hughitt went to Chicago as a telegraph operator for the Illinois and Mississippi

Telegraph Company, entering railway service in 1856 as a train dispatcher on the St. Louis, Alton & Chicago Railroad, now the Chicago & Alton. Later he was advanced successively to superintendent of telegraph and trainmaster and in 1862 he became superintendent of the Southern division of the Illinois Central Railway. Two years later Mr. Hughitt was promoted to general superintendent, leaving the Illinois Central in 1870 to become assistant general manager of the Chicago, Milwaukee & St. Paul Railway. He was appointed general manager of the Pullman Palace Car Company and in 1871 entered the employ of the Chicago & North Western Railway as general superintendent at Chicago. Mr. Hughitt was made general manager in 1876 and in 1880 he was elected vice-president and general manager. He was elected to the presidency in 1887. In 1882 he had been elected to the presidency of a subsidiary of the Chicago & North Western Railway, The Chicago, St. Paul, Minneapolis & Omaha. Mr. Hughitt served as president of the latter road until 1907, when he was elected chairman of its board of directors. Mr. Hughitt relinquished the chairmanship of the board of the two railroads in June, 1925, when he became chairman of the finance committee.

Benjamin F. Jones, Jr., chairman of the board of directors of the Jones & Laughlin Steel Corporation, died at his home in Pittsburgh, Pa., on January 1. Mr. Jones was the son of the founder of the corporation and was born on April 21, 1868 in Pittsburgh. He was educated at Princeton and after his graduation from college in 1891 entered the employ of Jones & Laughlin, Limited. He later served as treasurer and a member of the board of managers. In 1900 he became president, and when the Jones & Laughlin Steel Corporation was formed in 1923 he became chairman.

John Henderson, treasurer of the Edgewater Steel Company, Pittsburgh, Pa., since its organization in 1916, died on December 30. Mr. Henderson was born in Scotland in 1855, and has been identified with the steel industry since coming to this country in 1886. He started his business career with the Carnegie Steel Company. Later he was treasurer of the Latrobe Steel & Coupler Company and subsequently, treasurer of the Inter-Ocean Steel Company, of Chicago.

New Publications

Books, Bulletins, Catalogues, Etc.

Annual Report of The Smithsonian Institution for 1926. A profusely illustrated volume of 551 pages, published by the United States Government Printing Office, Washington, D. C.

In addition to outlining the activities of the institution during 1926, the report contains a general appendix in which are reproduced papers touching upon many fields of science and research. For the most part, the subjects treated are handled in a way to appeal to the average reader, and gives a vast fund of interesting and valuable information to the public at large in a rather fascinating manner.

Steam and Electric Railroad Cars and Railroad Repair Shops is the title of a booklet of twenty-one pages which has been issued by the U. S. Government Printing Office, Washington, D. C.

Tables give the number of railway repair shops in each state, the number of salaried officers and employes and average number of wage earners in the shops, grouped by states. Other tables show equipment, value of work and products and other pertinent figures, the whole being an abstract from the Census of Manufacturers, 1925, now in course of compilation.

History of Railroading in U. S. A., is the title of a folder of 22 loose leaves being distributed by the Bridgeport Brass Company, Bridgeport, Conn. Each leaf describes an interesting incident in railroad history. The incidents have been chosen because of their bearing on railroad development and each is illustrated by a drawing depicting equipment and practices existing at that time.

The Baltimore and Ohio Railroad Company and Its Subsidiaries.—A Bibliography compiled by Edmund A. Freeman, containing three hundred and seventy-eight pages, and published by the Library, Bureau of Railway Economics, Washington, D. C. The compiler is cataloguer in the Library of the Bureau of Railway Economics and the records of sixty libraries were checked in the making of this bibliography. Beside each entry is noted the libraries in which the item may be found so that one can locate the books he wants in the library nearest to his location.

Railway Accounting Procedure by E. R. Woodson. A book of one thousand and sixteen pages, Railway Accounting Officers' Association, Washington, D. C. Mandatory and recommendatory rules for railway accounting that will be effective in 1928, supplementd by a brief description of the work of the Railway Accounting Officers Association, and a continuation of the accounting bibliography which this year includes a new section on motor transport accounting.

Railway Journal Bearings—Catalogue No. 187 has been issued by SKF Industries, Inc., 40 East Thirty-fourth street, New York, and describes the SKF journal bearing for railroad equipment. This bearing is a self-contained and selfalining unit. No internal adjustment is required to the bearing itself, and complete freedom of alinement is assured in passing over rail joints and track irregularities. Cross sectional drawings clearly illustrate these features of the bearing.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

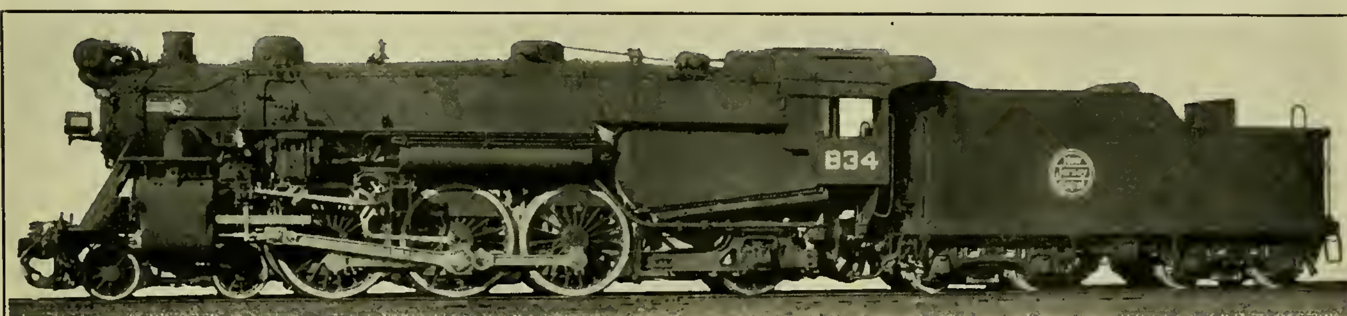
Vol. XLI | 136 Liberty Street, New York, February, 1928 | No. 2

New Pacific Type and Heavy Switching Locomotives of the Central of New Jersey

They Provide Increased Capacity Over Existing Engines in Passenger and Yard Service

The Baldwin Locomotive Works has recently delivered to the Central Railroad of New Jersey five Pacific or 4-6-2 type locomotives and ten heavy switching engines of the 0-8-0 wheel arrangement, both of which represent a further development of locomotives already in service on the road, but of increased capacity to meet the increased demands of passenger and yard service.

The five passenger locomotives of the 4-6-2 type will handle the heaviest through passenger trains of the road. These schedules include the express trains operated between Jersey City, N. J., and Harrisburg, Pa., and between Philadelphia, and Scranton, Pa. On the Harrisburg run the 179 miles is made in 4-hrs. and 50 min., eastbound. On the run between Philadelphia and Scranton grades of 59 ft. to the mile are encountered westbound and 96 ft. to the mile eastbound.



Pacific or 4-6-2 Type Locomotive of the Central Railroad of New Jersey—Built by the Baldwin Locomotive Works

These locomotives are similar to the previous design of 4-6-2 passenger engines employed by the road but with a number of changes in design of the details and the addition of improved specialties has provided an increase in power. The new engines carry a boiler pressure of 230 lb., as compared with 210 lb., used in the previous design.

The total weight of the new 4-6-2 type locomotives, loaded, is 326,470 lb. as against 306,000 lb. for previous locomotives of the same type and the weight on the drivers is 197,660 lb. instead of 196,000 lb. The sizes of the cylinders and drivers remain the same, the cylinders being 26 in. by 28 in. and the drivers 79 in. diameter over the tires. On account of increased boiler pressure, the tractive force of the new Pacific is 46,840 lb. compared with 42,768 lb. for the previous ones.

The boiler of the new 4-6-2 types is of the conical type and by reason of the increased pressure, the thickness of the third boiler course has been increased to 15/16 in. instead of 7/8 in. on the earlier 4-6-2 type, but the first and second courses remain as before, 13/16 in. and 7/8 in., respectively. The first course is straight and has an outside diameter of 78 in. while the second course is tapered to 86¼ in. outside diameter at the rear end, and the third course, on which a one-piece pressed steel dome is located, is straight and has an outside diameter of 88¼ in. In order to keep within weight limitations, the inside width of the firebox on the new Pacifics was made 96¼ in. instead of 108¼ in. as on the earlier design, but the inside length of the firebox remains the same, 126⅛ in., giving a grate area of 84.3 sq. ft. compared with 94.8 on the former.

The firebox has a sloping throat sheet and a 36-in. combustion chamber, and is equipped with three Thermic siphons and three arch tubes. The new 4-6-2 types are fired with a standard Type B stoker. A Type A superheater with 36-in. units is used.

Steam distribution is controlled by 13-in. piston valves actuated by the Walschaert valve gear. An Alco power reverse gear is employed.

The back end of the main rods and the middle connections of the side rods are equipped with floating bushings. The guides are of forged steel, with removable bottom wearing strips. The piston are light section steel castings and the piston rods are 5½ in. in diameter, are hollow bored and heat treated.

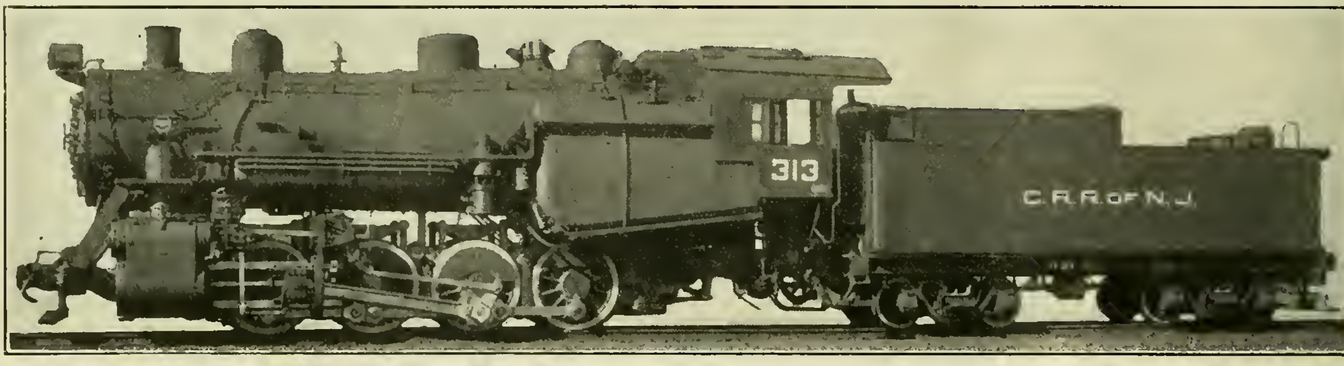
Other specialties included in the improved design are an Elesco feedwater heater which has the feed pump located on the left side of the boiler near the front end, a Nathan eight-feed mechanical lubricator, Commonwealth top equalizer, four wheel swing motion, integral pedestal type of cast steel tender trucks arranged for clasp brakes, and a Commonwealth cast steel type of engine truck with pedestals cast integral with the frame; a cast steel center plate supported on pear-shaped hangers, main locomotive frames of vanadium cast steel. The trailer truck is of the Commonwealth Delta type. These locomotives are also equipped with Chambers back head throttle valve; automatic drifting valve; chrome-silica-manganese driv-

DIMENSIONS AND WEIGHTS OF CENTRAL RAILROAD OF NEW JERSEY 4-6-2 AND 0-8-0 TYPE LOCOMOTIVES

Type of locomotive	4-6-2	0-8-0
Service	Passenger	Switching
Cylinders, diameter and stroke	26 in. by 28 in.	24 in. by 30 in.
Valve gear, type	Walschaert	Walschaert
Valves, piston type, size	13 in.	13 in.
Maximum travel	6½ in.	6¼ in.
Outside lap	1¼ in.	1 in.
Exhaust clearance	¼ in.	Line and line
Lead in full gear	¼ in.	⅛ in.
Weights in working order:		
On drivers	197,660 lb.	255,100 lb.
On front truck	65,850 lb.	....
On trailing truck	62,960 lb.	....
Total engine	326,470 lb.	255,100 lb.
Tender	217,000 lb.	171,300 lb.
Total engine and tender	543,470 lb.	426,400 lb.
Wheel bases:		
Driving	13 ft. 10 in.	15 ft. 3 in.
Total engine	36 ft. 8 in.	15 ft. 3 in.
Total engine and tender	72 ft. 2 in.	54 ft. 6⅞ in.
Wheels, diameter outside tires:		
Driving	79 in.	55 in.
Front truck	36 in.	....
Trailing truck	55 in.	....
Journals, diameter and length:		
Driving, main	12 in. by 14 in.	11½ in. by 12 in.
Driving, others	11 in. by 14 in.	10½ in. by 12 in.
Front truck	7 in. by 12 in.	....
Trailing truck	9 in. by 16 in.	....
Boiler:		
Type	Conical	Conical
Steam pressure	230 lb.	230 lb.
Fuel	Bituminous	Fine anthracite and bituminous
Diameter, first ring, outside	78 in.	78⅛ in.
Firebox, length and width	126⅛ in. by 96¼ in.	121⅝ in. by 108¼ in.
Arch tubes, number and diam	3—3 in.	5—3 in.
Siphons	2	None
Combustion chamber length	36 in.	None
Tubes, number and diameter	251—2 in.	208—2 in.
Flues, number and diameter	36—5⅜ in.	34—5½ in.
Length over tube sheets	19 ft.	15 ft.
Grate area	84.3 sq. ft.	91.43 sq. ft.
Heating surfaces:		
Firebox	292 sq. ft.	203 sq. ft.
Combustion chamber	64 sq. ft.	....
Arch tubes	23 sq. ft.	37 sq. ft.
Syphons	90 sq. ft.	....
Tubes and flues	3,444 sq. ft.	2,354 sq. ft.
Total evaporative	3,823 sq. ft.	2,594 sq. ft.
Superheat, surface	789 sq. ft.	574 sq. ft.
Comb. evaporative and superheat	4,612 sq. ft.	3,168 sq. ft.
Tender:		
Style	Water bottom	Water bottom
Water capacity	10,000 gal.	9,000 gal.
Fuel capacity	15 tons	13 tons
Journals, diameter and length	6½ in. by 12 in.	6 in. by 11 in.
Rated tractive force	46,840 lb.	61,422 lb.

ing and truck springs; and with the Union Switch & Signal Company's coded continuous automatic train control.

A Commonwealth one-piece cast steel water bottom tender frame is an innovation on these locomotives. The tender frame is so designed that the side sheets fit snugly into a recess extending the length of the tender frame, giving a smooth, tight joint, with the side sheets coming flush with the side of the steel underframe. The joint between the side sheet and the frame cannot be discerned when the tank is finished and painted, giving the tender a very neat appearance.



0-8-0 Type Switch Engine of the Central Railroad of New Jersey—Built by the Baldwin Locomotive Works

0-8-0 Type Switchers

The ten 0-8-0 switch engines are also an improvement on a design which has been employed on the road for some years. They will be used in the classification yard at Elizabeth, N. J., and in hump yard service in the freight yard located between Bethlehem and Allentown, Pa. These engines have a tractive force of 61,422 lb.

The cylinder and driving wheel dimensions of the switching locomotives are the same as in previous locomotives of the 0-8-0 type on this road, but the boiler pressure has been raised from 200 to 230 lb., giving a tractive force of 61,422 lb. compared with 53,411 lb. for previous designs. These switchers have been designed to traverse curves as sharp as 30 deg.

The boilers have been designed with an exceptionally large grate area, suitable for burning a mixture of fine anthracite and bituminous coal. The inside length of the firebox is 121⅝ in. and the inside width is 108¼ in., giving a grate area of 91.43 sq. ft. The boilers are of the wagon top type, radially stayed with a sloping back head. Open hearth steel plate is used for the boiler shell, the first course is 78⅛ in. outside. It is straight and is 13/16 in. thick, while the second course is ⅞ in. thick, tapered to 83⅞ in. outside diameter at the back end. A one-piece pressed steel dome of 1⅜ in. thick material is located on the second boiler course. There are two 16-in. diameter fire door openings. A fire brick arch supported on 3-in. tubes is used, and a Type A superheater of 34 units.

The throttle valve is of the Chambers back head type. Carbon steel main frames are used, suitably braced with cast steel bracing and the pedestals are provided with bronze shoes and mild steel wedges. Five of the locomotives are equipped with Detroit force feed lubricators and the other five with Nathan mechanical lubricators. They are also equipped with the Detroit four feed flange oilers.

Steam distribution is controlled by piston valves 13 in. in diameter, actuated by the Walschaert type of valve gear. An Alco power reverse gear is used.

Cast steel piston centers with a removable cast steel follower are used. The piston rods are of open-hearth carbon steel. The cross-head bodies are of cast steel, fitted with bronze cross-head shoes, and are of the alligator type. The main and side rods are of open hearth steel and both the back ends of the main rods and the main pin connections of the side rods are equipped with floating bushings.

Other specialties used are the following: Cast iron grates with steel supports; chrome-silica-manganese driving springs and carbon steel tender truck springs; Commonwealth cast steel tender frame; Scullin steel tender truck wide frame and cast steel bolsters.

Further details of both the passenger and switching engines are given in the accompanying table.

Gas Electric Car of the Toronto, Hamilton & Buffalo

The Toronto, Hamilton & Buffalo Railway recently placed in service on its Waterford division a gas-electric car. In service the car replaces a steam train which consisted of a locomotive, combination baggage car and smoker, and a coach. It makes four trips a day over the division so that its total mileage is 175 per day. The car was built by the Canadian Car and Foundry Company, the engine and electrical equipment being furnished by the Electro-Motive Company.

Gas-Electric Car for the Toronto, Hamilton & Buffalo Railway

The car is 59 ft. 8 in., long over the body, the distance between truck centers being 45 ft. 1 in. The width of the body being 9 ft. 9⅝ in., and height of floor above rail 4 ft. 2¼ in. The engine room and operating compartment, at the front, is 10 ft. ½ in. long, the baggage compartment, 16 ft. 7 in. long, the smoking compartment, 5 ft. 10 in. long, and the main passenger room 23 ft. 4 in. long. The seating capacity is 37 in the main room and 10 in the smoking room, a total of 47, the transverse seats on one side of the aisle accommodating 3 passengers each, and those on the opposite side 2 each.

The car underframe is built up of 6 in. Z-bar center sills, 5 x 3 in. angle side sills, ¼ in. pressed steel diaphragm and sills with ¼ in. top cover and 5/16 in. bottom cover plates, and built up body bolsters. The side framing includes pressed steel side posts, 7 in. channel steel end posts, 2½ x 2¼ angle vestibule corner posts, 4 x ½ in. steel bar belt rail, and sheathing of blue annealed roller levelled copper bearing steel.

The power is supplied by a Winton 6 cylinder 275 h.p. gasoline engine, with cylinders 7½ x 8½ in. It turns over at 1,050 r.p.m. The electrical equipment consists of a General Electric Co. DT-507-Ba 180 kw. generator with differential winding on the exciter, driven by the gasoline engine, 2 G.E.-292 450 v. motors, a CP-127 400 v. air compressor, with 25 cu. ft. displacement at 500 v., and a Cy-99-B 7½ h.p. radiator fan motor. The generator has a continuous rating of 420 amps. at 440 v., based on 65 degrees C rise by resistance. The exciter has approximately 4 kw. capacity at 60 v. The engine is started by 2 Leece-Neville Bendix starting motors, in addition to which there is compressed air starting mechanism, the air being supplied from the braking system main reservoir. The power plant is mounted crosswise of the car, with the generator directly behind the operator. The radiator cooling system is mounted

Passenger Compartment of Gas-Electric Car at the front of the car. The radiator fan motor, turning over at 1,800 r.p.m. built in behind the radiator, draws air through it and passes it upward and toward the rear of the car. The two traction motors have 52:19 gearing and are rated at 150 h.p. each. The gearing is suitable for maximum operating speed of 60 m.p.h. The motors are self-ventilated. The hourly rating is 275 amps. at 450 volts and continuous rating on shunt field is 210 amps. at 450 v. The motors weigh, complete with accessories, 4,600 lb. each. These motors are single turn machines with spring nose suspension. The air compressor and fan motor operate directly from the main generator voltage supply.

The leading truck, upon which the driving motors are mounted, has 7 ft. wheelbase; the wheelbase of the trailing truck, which is an idler, is 6 ft. 4 in. Both trucks are of Commonwealth design, the frames being of cast steel with integral pedestals and spring caps, the bolsters Commonwealth cast steel with integral center plates and the side bearings also Commonwealth cast steel. The journals are 5 x 9 in. The wheels are 33 in. diam., rolled steel, of A.R.A. standard contour, and the axles are of forged open hearth steel. The journal boxes are National malleable pedestal type for the standard A.R.A. 5 x 8 in. bearing and wedge, and the dust guards are wood with canvas anti-dust washer and reinforced with galvanized iron.

The interior finish of the main passenger room, smoking compartment, and vestibule, is in mahogany, with the wainscoting in Agasote. The baggage compartment is finished in poplar. The headlining is 1/16 in. sheet steel.

The car is heated by an Arcola no. 7 hot water heater, the heating pipes being Vulcan radiator tubing, 2¼ in. o.d., with 4¼ in. square fins. It is lighted by Safety Car Heating and Lighting Co. equipment. The air brakes are Westinghouse type A.M.L. Drawbars are National Malleable Castings Co. type with 6¼ x 8 in. spring draft gear. Pyle National electric headlight equipment is used on the car.

Report of the Bureau of Locomotive Inspection

Shows Substantial Decrease in Accidents and in Defective Locomotives

The annual report of A. G. Pack, chief inspector of the Bureau of Locomotive Inspection of the Interstate Commerce Commission, for the fiscal year ending June 30, 1927, indicates that there has been a decrease of 9 per cent in the number of defective locomotives and a decrease of 14.9 per cent in the number of accidents.

In this his fifteenth annual report, Mr. Pack has again commended those railways that have applied low water alarms in an effort to reduce the number of explosions caused by low water. A number of such devices have been developed that seem to have proved themselves reliable from the viewpoint of the users.

There was a substantial decrease in the percentage of locomotives inspected and found defective. During the year 31 per cent of the locomotives inspected were found with defects or errors in inspection that should have been corrected before being put in use, as compared with 40 per cent for the previous year and 46 per cent for the fiscal year ended June 30, 1925.

While there was a substantial decrease in the total number of accidents during the year, his investigations indicate that a still greater decrease should have resulted had the requirements of the law and rules been complied with, especially so with respect to defects the repairs of which are frequently considered unimportant.

Boiler explosions caused by crown-sheet failures continue to be the most prolific source of serious and fatal accidents with which we have to deal, 60.7 per cent of the fatalities during the year being attributable to this cause. There was a decrease of 48.7 per cent in the number of crown-sheet failures, but the average number of fatalities per accident increased, resulting in the same number of fatalities from the cause as occurred in the previous year. The fatalities per accident may be expected to increase with the increasing size of locomotives and the higher pressure carried in the boilers of modern locomotives. The investigations indicate that material reduction in this class of accident and resulting casualties can be accomplished only by proper location and maintenance of water-level indicating appliances that will accurately register the water level in the boiler under all conditions of service; the use of the safest practicable fire box construction, especially within the area which may be exposed to overheating due to low water; and the application of a device that will give an audible alarm when the water level approaches the danger point.

In his report, Mr. Pack shows the result of a boiler explosion due to the crown sheet being overheated caused by low water. The explosion, which resulted in the death of three persons, occurred while the locomotive was hauling a freight train at an estimated speed of 30 miles per hour.

The boiler was equipped with one water glass located on the left side of the back head, and three gauge cocks tapped horizontally into the right side of the back head close to the knuckle or flange of the wrapper sheet seam. The boiler was originally equipped with two water glasses, one on the left side of the back head and one on the right side, but the latter had been removed some time prior to the date of accident.

The impossibility of ascertaining the actual water level in the boiler when the locomotive is in operation from gauge cocks entered directly into the boiler back head, especially when in close proximity to the flange or knuckle, is well known. Recognizing that correct indication of water level indicating appliances is essential to safety, many carriers have equipped their locomotives with water columns with water glass and gauge cocks attached on the right side of the boiler back head, with an additional water glass located on the left side.

The various parts and appurtenances of steam locomotive and tender which through failure have caused serious and fatal accidents which if taken advantage of and proper inspections and repairs are made in accordance with the spirit and intent of law and rules a large portion of such accidents can be avoided. The graphic chart shows the relation between the percentage of defective steam locomotives and the number of accidents and casualties to persons resulting from failure thereof, and illustrates the effect of operating locomotives in a defective condition from the viewpoint of safety.

Reduced Body Stay Bolts

Attention has been called to the danger resulting from the use of reduced body stay bolts having telltale holes which do not extend into the reduced section at least five-eighths inch. Failure of this type of bolt usually occurs at or close to the fillet joining the body of the bolt and the enlarged ends. Telltale holes which do not extend into or beyond the usual point of breakage can not perform the function for which they are intended and mislead inspectors who depend upon the telltale holes as a check of the results of the hammer test.

When applying reduced body stay bolts, great care should be exercised to see that the bolts are of proper length so that the threads on the bolts engage the threads in the sheets for the full thickness of the sheets. If the bolts are too long, a full bearing for the threads is not obtained in each sheet and part of the bolt will blow out when breakage occurs usually with fatal results.

DERAILMENTS AND CASUALTIES CAUSED BY DEFECTS IN OR FAILURE OF PARTS OF THE LOCOMOTIVE OR TENDER. ONLY SUCH DERAILMENTS ARE REPORTED AND INVESTIGATED

	Year ended June 30— 1927	1926	1925	1924	1923
Number of derailments	15	23	22	30	38
Number of persons killed	1	2	..	3	4
Number of persons injured	23	49	52	112	157

Extension of Time for Removal of Flues

One hundred and forty-six applications were filed for extension of time for removal of flues, as provided in rule 10. The investigations disclosed that in eight of these cases the condition of the locomotives was such that no extension could properly be granted. Eleven were in such condition that the full extensions requested could not be authorized, but extensions for shorter periods of time were allowed. Twenty extensions were granted after defects disclosed by our investigations had been repaired. Eleven applications were canceled for various

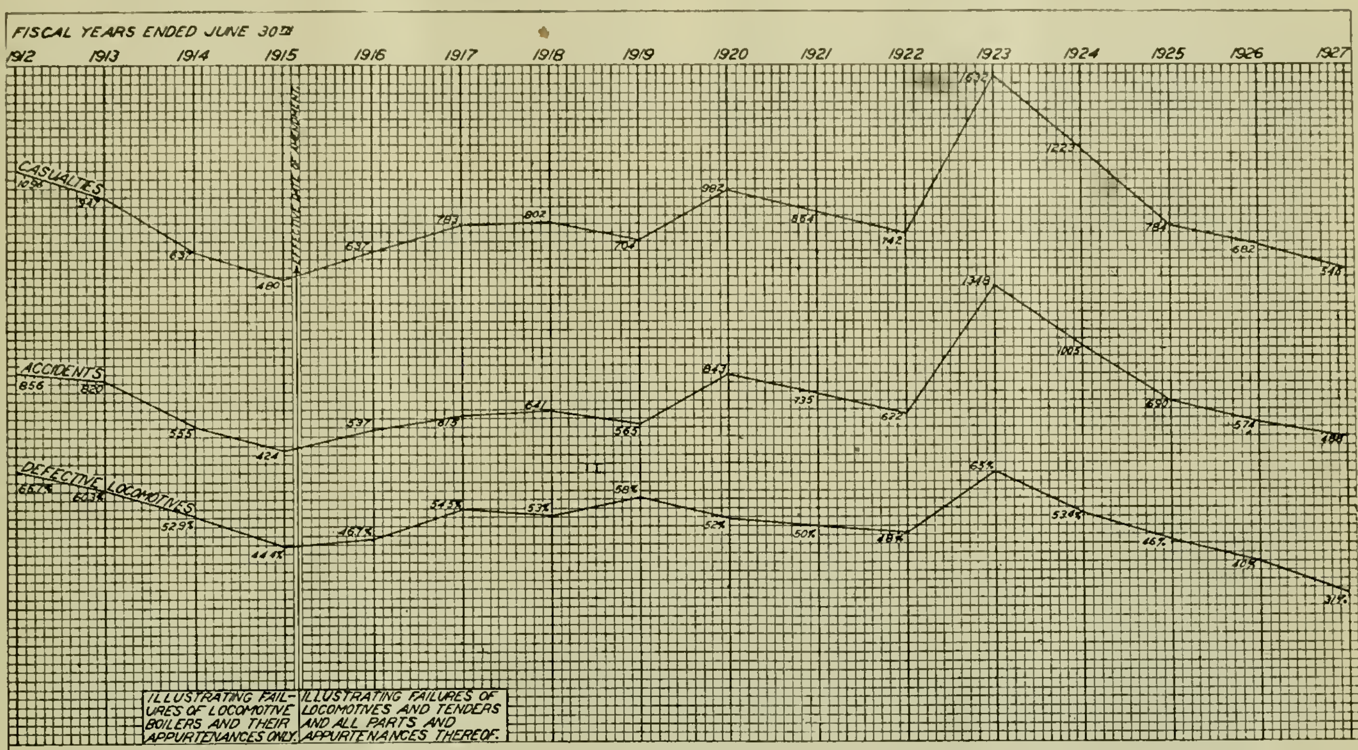


CHART SHOWING RELATION OF DEFECTIVE STEAM LOCOMOTIVES TO ACCIDENTS AND CASUALTIES RESULTING FROM LOCOMOTIVE FAILURES.

ACCIDENTS OR CASUALTIES CAUSED BY FAILURE OF SOME PART OF THE LOCOMOTIVE OR TENDER

	Year ended June 30— 1927	1926	1925	1924	1923
Number of accidents	488	574	690	1,005	1,348
Per cent increase or decrease from previous year	14.9	16.8	31.3	25.5	[1]117
Number of persons killed	28	22	20	66	72
Per cent increase or decrease from previous year	[1]27.3	[1]10	69.7	8.3	[1]118
Number of persons injured	517	660	764	1,157	1,560
Per cent increase or decrease from previous year	21.6	13.6	33.9	25	[1]120

[1] Increase.

PERSONS KILLED AND INJURED CLASSIFIED ACCORDING TO OCCUPATION

	1927 Killed	1927 Injured	1926 Killed	1926 Injured	1925 Killed	1925 Injured	1924 Killed	1924 Injured	1923 Killed	1923 Injured
Members of train crews:										
Enginemen	8	181	5	210	8	230	19	330	19	484
Firemen	9	179	6	230	6	300	22	434	16	597
Brakemen	4	51	3	77	2	84	9	102	12	137
Conductors	...	25	2	28	...	25	2	39	1	35
Switchmen	1	13	...	19	...	23	1	29	2	32
Enginehouse and shop employees:										
Boiler makers	...	11	...	5	...	6	1	24	3	19
Machinists	1	5	...	5	...	13	1	9	2	14
Foremen	...	1	...	3	...	...	1	6	1	6
Inspectors	...	...	...	...	...	2	1	3	...	2
Watchmen	2	4	1	5	1	3	...	5	1	6
Boiler washers	1	2	...	2	...	5	2	5	1	9
Hostlers	1	7	...	9	...	16	...	14	...	31
Other enginehouse and shop employees	...	19	1	15	...	10	6	34	4	29
Other employees	1	10	3	10	1	13	...	16	4	36
Non-employees	1	9	1	42	2	34	1	107	6	123
Total	28	517	22	660	20	764	66	1,157	72	1,560

reasons. Ninety-six applications were granted for the full period requested.

Recommendations for Betterment of the Service

In his former report recommendations were made by Mr. Pack, in accordance with section 7 of the act, as amended, for the application of automatic fire doors, power reverse gears, power grate shakers, horizontal hand-holds, stirrups on cabs, and water columns with water glass and gauge cocks attached with an additional water glass located on the left side or boiler back head, and reasons given therefor.

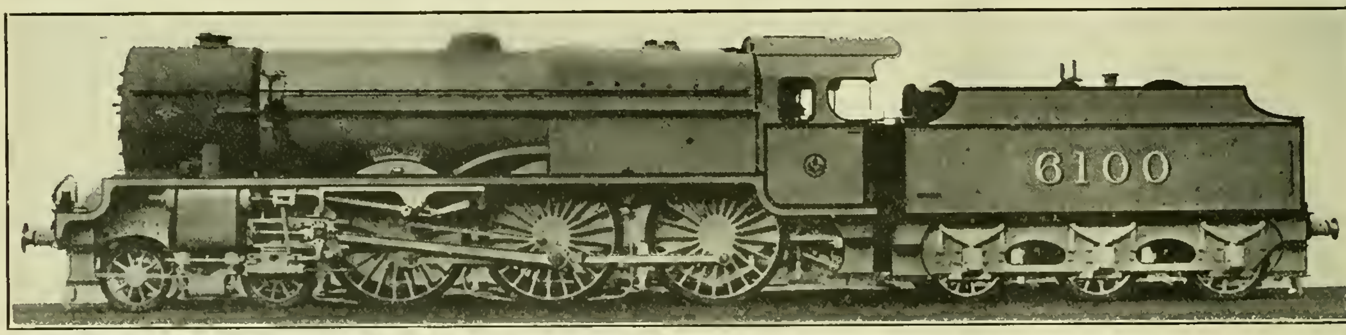
While many of the carriers have recognized the value of these appliances and considerable progress has been made in the application thereof, the installations are not progressing as fast as could be desired to obtain the maximum degree of safety; therefore the recommendations are respectfully renewed. Mr. Pack feels that these recommendations should be made a requirement of the rules.

A 4-6-0 Three Cylinder Single Expansion Locomotive

A Ten-Wheeler for Express Passenger Service

Fifty 4-6-0 type locomotives having three single-expansion cylinders were built last Fall for the London, Midland & Scottish Railway by the North British Locomotive Works, Ltd. They represent the designs of Sir Henry Fowler, chief mechanical engineer of the railway company.

These engines are designed to develop a tractive effort of 33,150 lb., at 85 per cent of the boiler pressure which is 250 lb. The inside cylinder drives on the crank axle of the leading pair of coupled wheels, and the outside cylinders the middle pair, each being provided with a separate Walshaert valve gearing. The boiler and firebox are large and ample grate area is provided. A great deal of attention was directed to the boiler proportions, which were finally settled largely on previous experience with an existing type. This combination of high boiler pressure with considerable firebox volume in conjunction with a large total heating surface, and grate area of 31.25 sq. ft., is a distinguishing feature of the design, which has been specially planned to provide sufficient power to haul efficiently the heavily-loaded express passenger trains on the main lines between London, England, and Glasgow, Scotland.



Three-Cylinder, 4-6-0 Type Locomotive of the London, Midland & Scottish Railway

It will be noted that the length of the firebox is 10 ft. 3 in., which is rather long, particularly for hand firing, but it is provided with a drop gate for cleaning or removing the fire. The drop gate is operated from the cab by means of hand lever.

The standard type superheater is used, other equipment including Davies and Metcalfe's exhaust steam injector; vacuum pump, in conjunction with standard large and small Dreadnought ejector; Ross patent pop safety valves; and a steam tube-cleaner. In addition, standard locomotive fittings have been provided wherever possible to facilitate interchangeability. A mechanical lubricator supplies oil to the cylinders, piston valves and spindles, and piston rods, while a second mechanical lubricator feeds oil to the coupled axle-boxes.

As the boiler is pitched rather high the whistle has had to be set in a horizontal position to clear the gauge, and for the same reason a special pop safety valve has been designed.

The total weight of the engine is 190,175 lb., of which 140,000 lb., is on the drivers. The locomotive is equipped with steam brakes on both the driving and truck wheels. Steam brakes are also provided on the tender.

Other details of the engines are given in the table.

In a discussion before the Institution of Mechanical Engineers, London, last month, Sir Henry Fowler gave some figures from dynamometer tests of the performance of the first of these engines the "Royal Scot." On the non-stop run from Euston to Carlile with 503.6 tons behind the tender the train was handled at an average speed of 53 miles per hour, the coal consumption being .078 lb. per ton mile. With an additional 51 tons behind the engine, the fuel consumption on the easier grade between Euston and Crewe was as low as .067 lb. per ton mile.

The calorific value of the coal used in the trials is about 14,050 B.T.U.

With the heaviest train tried, on the run between Euston and Crewe, the fuel consumption and water per draw-bar horsepower was down to 2.66 lb. of coal and 22.3 lb. of water.

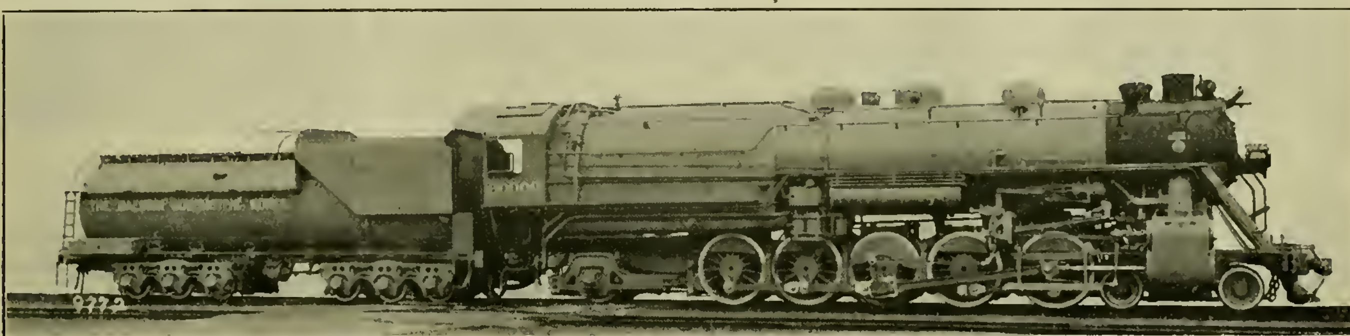
Cylinders (3) diam.	18 in.
Cylinders, stroke	26 in.
Driving wheels, diam.	6 ft. 9 in.
Wheelbase (engine)	17 ft. 6 in.
Wheelbase, rigid	15 ft. 4 in.
Weight on drivers	140,000 lb.
Boiler working pressure	250 lb. per sq. in.
Heating surface, tubes	1,892 sq. ft.
Heating surface, firebox	189 sq. ft.
Total evaporative heating surface	2,081 sq. ft.
Heating surface superheater	445 sq. ft.
Grate area	31.2 sq. ft.
Tractive effort at 85 per cent boiler pressure	33,150 lb.
Weight of engine in working order	190,176 lb.
Weight of tender in working order	95,648 lb.
Total weight of engine and tender	285,824 lb.
Tender, water capacity	3,500 gallons
Tender, coal capacity	5½ tons

Progress in Railroad Mechanical Engineering

Railroad Division Report of the American Society of Mechanical Engineers

As 1927 was the centenary of various railroad systems in this country, the recent and most elaborate celebration being that of the Baltimore & Ohio Railroad, it may not be out of place in this year's report to include a few figures which will briefly indicate the colossal proportions to which the American railway system has grown during the past 100 years.

The total investment in Class I roads now amounts to more than 24 billions of dollars; their mileage is in excess of 250,000, representing more than one-third of the world's total. On January 1, 1927, these roads operated 62,800 steam locomotives, which had an aggregate tractive power of 1,304,000 tons. As of the same date, these roads operated 2,350,000 freight cars which had a total carrying capacity of 105,717,000 tons. Over 1,000,000 cars were loaded each week during the year, and they carried 3,791 tons of freight one mile for each inhabitant of this country. These figures give a background for an appreciation of the important place in the economics of this country, which is occupied by our basic transportation industry. Lack of progress in development, and particularly in all of the engineering problems involved, would be a deterrent in the business and economic life of our nation. Such depressing effect, while it cannot be evaluated, would be admittedly enormous. A record of the progress which railway mechanical engineering has made, therefore, is always of value, and as the centenary of railroad beginnings is occurring, it becomes of more than ordinary interest.



Three-Cylinder Experimental Compound Locomotive Built by the Baldwin Locomotive Works

During the past year the progress in railway mechanical engineering has been steadily toward bettering the operating efficiency of railroads by continuing the effort to increase the gross ton-miles per freight-train-hour. This unit is becoming generally recognized as a most valuable index. Part of the accomplishment is due to heavier and more efficient motive power, part to improvements in signaling, heavier car loading, etc.

"Railroad efficiency is a factor of national prosperity" has been a motto always in the mind of progressive railroad men. Efficiency in the purchasing and maintenance of stock material suitable for the requirements, but not involving an unnecessary investment, is an activity which during the past year, has made marked progress. Intensive effort to avoid excessive surplus material has been made.

That some, at least, of the views expressed in previous reports of this committee have been brought into reality may be evidenced from the following quotation of a leading railroad executive:

"From the mechanical viewpoint, the most significant developments in the railway field are the design and construction of high-pressure steam locomotives, of oil-electric locomotives, and of very high-capacity electric locomotives; the application and operation of capacity- and efficiency-increasing devices to what may be called the normal type of steam locomotives, and the design and construction of locomotives of this same normal type so that they show more reliability in service, more economy in operation, and have a lower annual repair cost and a longer life."

The campaign for greater economy in the use of fuel, in which the International Railway Fuel Association and the Traveling Engineers' Association have been factors of great importance, has made progress during the present year.

The average daily movement per freight car for the first seven months of 1927 was 29.8 miles, the highest mark ever attained in any corresponding period, according to reports filed with the Bureau of Railway Economics. This was an increase of one-half mile above the best previous average established in the first seven months of 1926.

The campaign for greater safety, while not a mechanical-engineering problem, is of such intense human interest that endorsement of these efforts is not out of place in this report, and such endorsement is heartily given.

Progress in standardization of weighing equipment complying with the requirements of the American Railway Engineering Association and of the Bureau of Standards, has been reported as having made marked advancement during the current year.

Motive Power

The tendency toward higher steam pressures in locomotive boilers is going forward, the Delaware & Hudson Company having put in service its 400-lb. John B. Jervis, and the Pennsylvania is engaged in designing a 2-10-0 type with 450 lb. pressure. Auxiliaries are operated with superheated steam; enlarged grate areas, and greater firebox volumes are being used in increasing numbers, as are also feedwater heaters and exhaust-steam injectors. Three-cylinder locomotives are being bought in considerable numbers.

Experiments are still being conducted with oil-electric locomotives in switching service. The Chicago & North Western have added storage batteries in order to reduce the weight of the primary power plant.

The effort toward long locomotive runs is continuing, and in this effort larger tenders and a better spacing of water stations are proving effective.

Cast-steel underframes for tenders are being more extensively used, and experiments are being conducted with one-piece cast-steel locomotive frames and, on one road, with a cast-steel smokebox.

There is increased activity in and development of a modified boiler construction permitting more satisfactory service, not only for use with higher steam pressures, but with consideration of better water circulation and the reduction of corrosion effects. Consideration is also being actively given to the proper adaptation of condensing operation as well as to the use of air preheaters.

Reference to Table 1 shows the marked increase in the use of four-wheel trailing trucks on locomotives. It is to be noted also that practically all of the new and advanced designs of locomotives constructed during the year have had this feature, and also that a large proportion of the new designs have been built for steam pressures ranging between 220 and 300 lb. per sq. in. The tendency in this particular, mentioned in previous reports, has been progressing during the current year. A number of the new designs of locomotives have made use of nickel, or silicon, alloy steel for the shell plates of these higher-pressure boilers. Reports of the service of this material have not shown any indications of difficulties, and the advantages in reduced weight for a given set of conditions appears to have been realized.

Indications, from the records covering the first half of 1927, encourage the belief that the fuel savings on locomotives will amount to approximately $17,000,000 as compared with the year 1926. The consumption per 1000 gross ton-miles in freight service for the first four months of this year was less than for the corresponding period during the year 1926. If this rate of reduction is maintained, the 1927 figure will be 129 lb.

Rolling Stock

Experiments are being made with lacquers for both the exterior and interior finish of coaches and dining cars.

A number of railroads are putting motor buses on the highways as feeders to, as well as paralleling, their steam routes. Larger and higher-powered motor rail cars have been developed to haul one or two trailers.

The rapid advance in the use of self-propelled cars is evidenced by the fact that over 200 of such units were purchased during the first half of the year 1927.

The American Railway Association standard box car has been designed, and plans are being prepared for hopper and gondola cars. One road is experimenting with a solid cast-steel underframe for freight cars. Improvements in refrigerator cars involve trials of the "silica gel" process and "dry ice" or solid CO_2.

Automobile cars of new design, embodying side doors 12 ft. in width, have been built by the Chicago, Milwaukee & St. Paul, the Missouri, Kansas & Texas, and other roads, to meet an urgent demand from automobile manufacturers for cars with wide side doors, so that easier loading of completed automobiles is afforded. Reference should be made also to the 70-ton hopper gondola cars put in operation during the past year by the Delaware, Lackawanna & Western Railroad.

2-8-4 Type Locomotive of the Erie Railroad—Built by the American Locomotive Company

Economics

From the economic standpoint, we have the benefits realized by shippers and merchants because of the rapid and reliable movement of freight and passenger traffic; the rapidly increasing safety of travel, and especially the steadily decreasing net income of the carriers, which follows the many reductions in freight rates on the one hand and the alarmingly rapid increase in taxes and in payments to railroad workers on the other.

It is gratifying to note a change in public sentiment toward corporate interests, and particularly toward the railroads. A more sympathetic and appreciative viewpoint on the part of the public toward the progressive efforts of the railroads cannot help but have a beneficial effect upon all interested parties.

Greater efforts toward informing the general public of the engineering and operating progress is proving a wise move, and the railroad industry in general is to be commended for its efforts in this direction.

From the political standpoint, we have the growing political power of the standard labor unions; the desire of many politicians to stimulate railroad consolidation and to reduce freight rates, without regard to the cost of the

TABLE 1—DATA ON NEW DESIGNS OF LOCOMOTIVES

Road	Type of engine	Boiler pressure lb.	Cylinders No.	Cylinders Max. hp.	Type of superheater	Back-pressure gage	Feed-water heater or injector	Max. cut-off, per cent	Throttling between super-heater and steam chest	Grate area, sq. ft. Total	Grate area, sq. ft. per 100 hp.	Remarks
A. T. & S. Fe	4-8-4	210	2	3150	E	None	FWH	88	Yes	108.4	3.44	Mult. throt.
B. & O.	4-6-2	200	2	2252	A	None	—	85	No	66.7	2.96	......
Can. Natl.	4-8-4	250	2	2705	E	With	FWH	85	Yes	84.3	3.11	Mult. throt.
C. B. & Q.	2-10-4	250	2	4000	E	With	FWH	65	Yes	106	2.65	Mult. throt.
C. & N. W.	2-8-4	240	2	2915	E	With	FWH	60	Yes	100	3.43	Mult. throt.
D. & H.	2-8-0	300	2	3121	E	With	—	75	No	99.8	3.19	......
D. L. & W.	4-8-4	250	2	3036	A	With	—	85	—	88.2	2.9	......
D. & R. G. W.	2-8-8-2	240	4	5100	A	With	FWH	70	Yes	136.3	2.68	Mult. throt.
Erie	2-8-4	250	2	3130	E	With	FWH	81	Yes	100	2.9	Mult. throt.
G. T. W.	4-8-4	250	2	2870	A	With	FWH	88	Yes	84.4	2.94	Mult. throt.
I. H. B.	0-8-0	205	3	2829	A	With	FWH	84	Yes	72.5	2.56	Mult. throt.
N. Y. C.	4-6-4	230	2	2580	E	With	FWH	86	Yes	71.5	2.77	Mult. throt.
O. I. M. Co.	0-8-0	235	2	2070	A	None	FWH	80	Yes	63.0	3.14	Mult. throt.
So. Ry. of Eng.	4-6-0	220	4	—	—	—	Inj.	—	—	33.0	—	......

service; and the thinly veiled designs of many to work toward Government ownership of the railways.

The increase in efficiency and reliability of the railroads, since 1920, has affected the every-day life of every individual. There have been no strikingly important changes in the machinery of processes during that period, although large sums of capital have been invested in the direction of modernizing and increasing the capacity of the railway plant.

Progress in extending the use of automatic train control, improved automatic signal systems, and more efficient operation in freight classification yards is also to be recorded for the year.

Technical Training

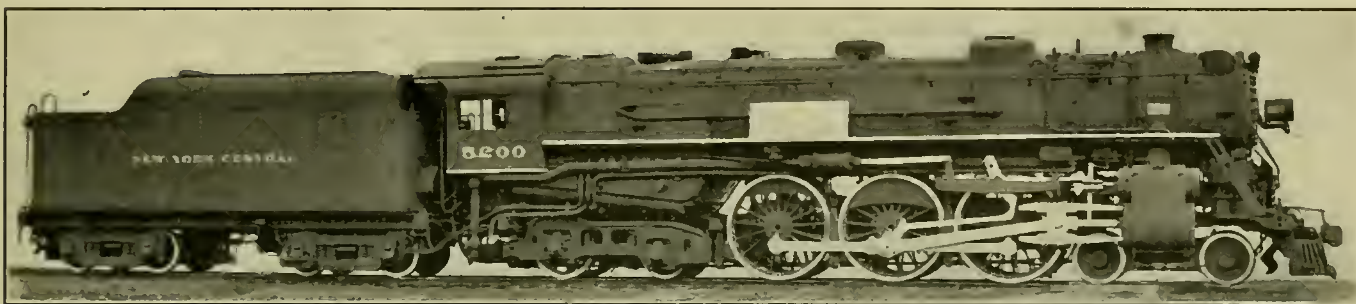
Questionnaires were sent to all the technical schools and colleges that maintain courses designed to prepare students for railway-mechanical-engineering work. The replies show that the various educational institutions are beginning to feel the results of a greater effort on the part of the railroads and railway-supply companies to cooperate in the training of men for their respective industries. In addition, the American Railway Association has been utilizing the laboratory and test facilities afforded by the various educational institutions, especially at Purdue University.

The Pennsylvania State College has for some time been studying the problem of insulation and heat transmission, factors in the efficient insulation and cooling of refrigerator cars and the heating of passenger cars. Considerable progress in this work has been made in the past year.

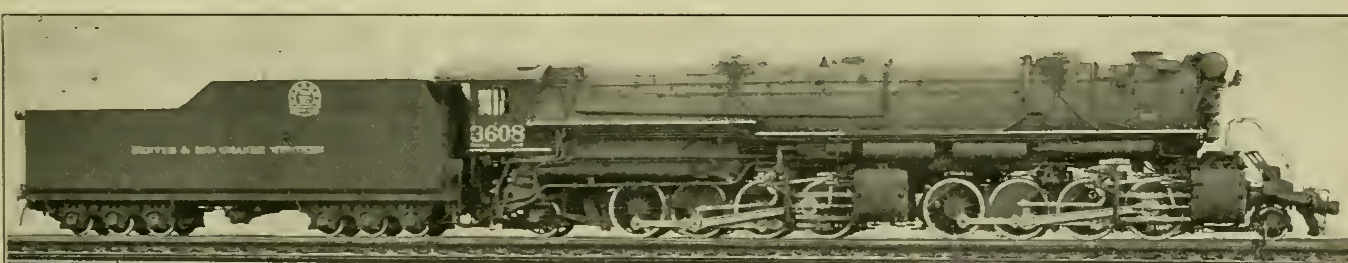
A number of radical changes are being considered in the courses of study offered to students in railway mechanical engineering. For a number of years different institutions have maintained courses in their curricula leading to the degree of Bachelor of Science in railway mechanical engineering. Among the most prominent have been the University of Illinois, Purdue University, Pittsburgh University, and The Pennsylvania State College. Some of these institutions abandoned the course a number of years ago and combined the railway course with the straight course in mechanical engineering, along much the same lines as the average course of study in civil engineering. Pittsburgh University, it is understood, and the Pennsylvania State College are, however, still maintaining a course in railway mechanical engineering. The latter institution, however, is seriously considering the abandonment of this course and including the more important railway subjects in its mechanical-engineering course.

In many respects this trend in railway-mechanical-engineering education will be beneficial from the standpoint of both the railroad and railway-supply industries. It is generally felt that mechanical engineers should have as broad an education as possible, and that specialization in college is not beneficial. It is also felt that a considerable improvement can yet be had in the educational field by a more careful selection of students in mechanical engineering, the installation of some scheme of vocational guidance, and the planning of the course of study to more adequately serve the mechanical engineer in railroad work dealing with steam turbines, gas engines, electric traction, etc.

The outstanding development in this field of education, from the standpoint of the railroad and railway industries, is the cooperative plan in engineering and commerce instituted several years ago by the Georgia School of Technology. The original plan of cooperative education for engineers was first instituted in September, 1920, when the textile department of that institution arranged a course, to cooperate with the cotton mills, in the education of textile engineers. Since that time the cooperative plan has been extended to a number of railroads; viz., the Central of Georgia, the Tennessee Coal, Iron & Railway Co., the Georgia Railway & Power Co., the Atlanta, Birmingham & Coast, and the Nashville, Chattanooga & St. Louis. Under the cooperative plan the student spends alternately four weeks in mechanical-engineering work in the railroad shops at Atlanta, Ga., and the cities within a radius of about 300 miles. By this arrangement the Georgia School of Technology has available two courses in mechanical engineering: viz., the standard four-year theoretical course as given by other engineering colleges, and a five-year course for those students who wish to combine practical experience with technical theory. The cooperative course is under the administration of a director, an assistant, and an advisory board consisting of



"Hudson" or 4-6-2 Type Locomotive Built by the American Locomotive Company



2-8-8-2 Type Simple Mallet Locomotive of the Denver & Rio Grande Western Built by the American Locomotive Company executives and officers of the various industrial and railroad companies with which the school cooperates.

The research work that is being carried on by the Railroad Division's Committee on Professional Service shows that the opportunities afforded in the railroad industry are comparable to those afforded in any other industry. In all probability there will be a larger number of mechanical engineers entering railroad work in the future. It is believed that an institution offering courses in mechanical engineering could offer a better-balanced course if the design and operation of motive power and rolling stock were included in the mechanical-engineering curriculum.

Trend in Development

Closer cooperation between technical schools, the railroads, and railway-supply companies is being evidenced. Technical schools more and more are requesting the services of mechanical engineers from the railway and railway-supply industries in bringing practical outside viewpoints before the under-graduates.

Aeronautical transportation, as an adjunct to rail transportation, has been given great impetus during the past year. Notice must be taken of the recent opening, by the American Railway Express Company, of its transcontinental air service, and the indications point toward an even more pronounced development in this field. Aerial transport coordinated with train service under railway-company operation, as well as by independent companies, may confidently be looked for within a relatively short time.

Research and development work in insulation and heat transmission as applied to refrigerator cars and steel passenger cars will be continued, and rapid progress is anticipated.

Iceless refrigeration has been already developed to a point where its advantages in the railway field have been demonstrated, and its extensive use appears to be forecast.

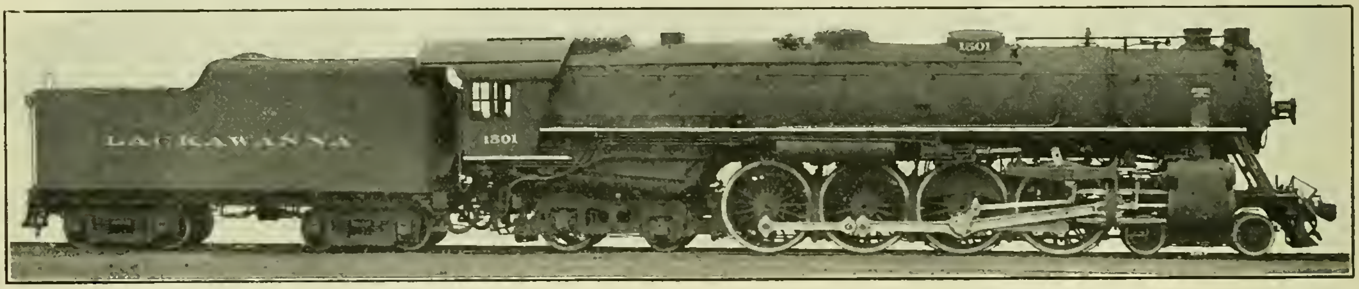
Motor-truck and bus service has been extended. Particular attention is being given to determining conditions under which further extension, from the standpoint of economy and advantageous coordination with steam service, may be made. Mention must also be made of the increase in "auto-bus tours" as an adjunct to passenger travel. In this field the Atchison, Topeka & Santa Fe and the Southern Pacific are the best known. The indications are that there will be considerable increase in such auxiliary services.

The development of the Diesel-electric power units, suitable for rail motor cars, with a weight of engine and generator of not over 26 lb. per hp. has been brought to the Committee's attention. Light-weight units of this character and of a size and flexibility suitable for rail-motor-car use offer encouragement to the further adaptation of this equipment in the not-far-distant future.

Diesel-electric locomotives, arranged for multiple-unit control and suitable for road service, are under construction for the New York Central Railroad. The Ingersoll-Rand Company, the McIntosh & Seymour Corporation, and the General Electric Company are developing and perfecting this method of control.

The American Railway Association's draft-gear tests at Purdue Univeristy were started with encouraging results during the year. The same association has made progress also in its research into the question of truck side frames, and the results of this important work should, and undoubtedly will, prove of great benefit to the railroad industry.

Some attention has also been given toward applying mechanical draft to locomotives by using turbine-driven fans for forcing air below the grates. The question of the use of pulverized fuel also has received further attention. Definite reports as to the amount of progress which has been made along these lines have not been available.



4-8-4 Type Locomotive of the Delaware, Lackawanna & Western—Built by the American Locomotive Company

Efficiency in the use of fuel, particularly as affecting the smoke-abatement problem, has been actively pursued and considerable progress reported. St. Louis is the center of the greatest activity in this subject.

The interest which the railways in the United States and Canada have in the application of roller-bearing journals has shown a marked increase within the last 12 or 14 months, particularly since the American Railway Association's Atlantic City Convention of June, 1926, at which time exhibits of trucks and other equipment thus fitted attracted no small amount of attention. Prior to this time several railways had been operating a small number of test cars. Within the last 18 months, four prominent trunk-line railroads have placed orders for 480 roller-bearing-equipped passenger cars of all types, all of which are now in service. The largest single order yet placed was for 133 cars. At the present time most of the other roads are disposed to watch the results obtained from the roller-bearing equipment in service rather than to proceed with any wholesale experimenting themselves. It is evident, however, that within the next year or two the manufacturers and the railroads will be possessed of useful data on the operating conditions of this type of bearing, as well as upon the relative merits of competitive types. Particularly is the latter true, as many of the operating advantages have already been well defined by actual tests.

The increase in size of motive power, the length of trains, and the larger-capacity cars now in use have brought about modification and improvement in draft gears which provide for the more severe service conditions. The problem of slack control in draft-gear design is another subject in which progress has been made. The much better condition in which air-brake apparatus is now maintained by the railroads is to be noted. Research in the air-brake field has been continuous and has resulted in the bringing out of a new type of feed valve having greater stability, reliability, and capacity, and a reduced cost in operation and maintenance. There have also been developments in brake-cylinder pressure-retaining valves and in the methods for more uniform application and release of brakes in passenger trains. The increasing use of higher steam pressures and higher steam temperatures has influenced development in air compressors and governors.

The increasing length of passenger trains has been appreciated by the manufacturers of train-heating equipment, and the past year has seen the application of train-heating equipment giving greater assurance that the rear cars of these long trains would be adequately heated. In this development, progress has been made in adapting modifications to the requirements of interchangeability between cars thus equipped and others, which is essential for further development in this direction.

The probable trend of development in the railway field within the next few years will be in the direction of enabling the railways to obtain a greater net income than has been the case during the last ten years. This increase in net income is necessary if the railway plant is to be enlarged so that it may, promptly and effectively, perform the work which it will be called upon to do, and, also to enable it to operate at a cost that its patrons can afford to pay.

Our Railways Have Come Back

By W. E. Symons

For years one of the popular pastimes of a large percentage of those who influence public opinion, was to abuse the railways. The road to political preferment seemed to be particularly inviting to those who maintained a constant propaganda against corporate interests, particularly railway corporations. If the misrepresentations, falsehoods, lies villification and abuse that had been directed against our railways were cause for imprisonment, our jails would not hold half the offenders.

When the government took over our railways in 1917 they were in a badly run down condition and when turned back to their owners they were in a much worse condition physically, while the morale of the forces was at about the lowest ebb possible. In this situation the public demanded 100 per cent service at once, which, of course, was a physical impossibility. As a measure of relief the Transportation Act of 1920 was passed and under its provision our railways have made a most remarkable come back.

Following the passage of the 1920 enabling act however, the petty politician and men of his ilk continued to assail the railways as before, thus impairing their credit and in other ways placing every possible obstruction in the way of their recovery. Many high grade publications carried in their columns numerous contributions detrimental to railway prosperity that were gross misstatements of well known facts.

With an unsympathetic and often hostile public to deal with our railways have fully demonstrated the superiority of private management over government control, and as a whole have made a good showing in a financial way as the following statistics will show.

Gross revenues, expenses, net from operations and net income for the average of the years 1916 to 1920 and 1921-1922-1923-1924-1925 and 1926.

Year	Gross Revenues	Expenses	Net Revenue From Railway Operation	Net Railway Income
1916 } 1920 }	$4,763,039,000	$3,897,220,000	$883,819,000	$616,987,000
1921	5,516,598,000	4,562,668,000	953,930,000	600,937,000
1922	5,599,093,000	4,414,522,000	1,144,570,000	760,187,000
1923	6,289,589,000	4,895,167,000	1,394,413,000	961,955,000
1924	5,921,496,000	4,507,885,000	1,413,611,000	973,837,000
1925	6,122,510,000	4,536,880,000	1,585,630,000	1,121,077,000
1926	6,380,092,000	4,666,225,000	1,713,867,000	1,213,543,000

The foregoing is a good example of what private management can do, if given fair rates and simply let alone for a reasonable period of time.

From the next following table may be seen the unending stream of money that flows into the maintenance of American railways to keep them up to the standard requirements of American life and traffic.

Year	Total New Money for Improvement and Construction
1916 1920 (5 years)	$646,828,910
1921	352,665,920
1922	523,847,780
1923	464,516,450
1924	779,617,069
1925	380,280,730
1926	345,991,000
Total	$3,491,747,859

From a study of the above tabulation showing the additions of $3,491,747,859 new capital in our railways during the eleven year period 1916-1926, it will be apparent why the valuation has increased from $18,139,409,955 in 1916 to $25,730,895,734 in 1926. The foregoing tabulation includes only the increase in stocks and bonds for the eleven years. The increased investment, however, from 1912 to 1925 inclusive, amounts to $7,377,907,191, so it must be clear to those who are fair minded that the present investment figure of $25,730,895,734 is a conservative one.

During this period of general railway prosperity there have been, of course, a few exceptions to the rule in that a few of the smaller "weak sisters," remain about as they were 5-10-or 20 years ago, while included with some 42 road in the hands of receivers, was the St. Paul with 11,205 miles, and a capitalization of $671,745,915. The St. Paul receivership was terminated Feb. 1, 1928.

The failure of this one time leading railway of the northwest, has been ascribed by unbiased students of the situation, to unwise actions in building across two mountain ranges, calling for expensive construction. A Pacific coast extension, that traffic demands did not justify.

Among the roads that have staged a most remarkable come back is the Erie, and when we speak of the Erie, those of the older school, or who recall railway history of another generation, think of the great characters who played so prominent a part in its early history. The names of Daniel Drew, Dean Richmond, Jay Gould, Jim Fisk, and in a social way, Josie Mansfield.

For decades, the Erie has been the butt of the joke maker, and in a financial way was on the verge of bankruptcy and receivership. It now looks, however, as though about all the prophesies as to the evil days in store for the Erie, would not come true after all. Let us see what has happened to the Erie's financial status during the past few years.

During 1922 the market price of Erie stocks was as follows:

First Preferred Stock, $15 per share	$ 7,185,660
Second Preferred Stock, $11 per share	1,760,000
Common Preferred Stock, $10 per share	11,240,000
	$20,285,660

Present prices of Erie stock is about as follows:

First Preferred Stock $63. per share	$ 30,179,772
Second Preferred Stock $61. per share	9,760,000
Common Stock $64. per share	71,988,416
Total Jan. 1928	$111,928,188

It therefore appears that the shares of Erie stock have a selling or market value today of about $91,642,528 more than they had a few years ago, and for which there must be some cause or reason. Aside from the beneficial effects of the Transportation Act to our railways in general, which includes a much changed public attitude toward corporate interests, the Erie has changed hands. The Van Sweringen interests acquired in 1924, did not acticely participate in the management of the physical property until 1927 at which time Mr. Bernet, formerly president of the "Nickel Plate" was elected president and at once took active charge of the Erie. Immediately following Mr. Bernet's taking charge, things began to not happen, but to take place in accordance with a well prearranged plan. The whole transportation unit was drastically reorganized from "Stem to Gudgeon," and the results already achieved, plus the anticipated future returns, furnish material for writing a new and brighter page in the history of the Erie.

Among the more important changes made was a complete reorganization of the operating, stores, and mechanical department, resulting in great economies.

One of the first things Mr. Bernet did was to order eighty (80) new locomotives, fifty of these are of an improved 2-8-4 type (a modified Mikado, known as the Berkshire type).

These engines are now in service, and reports show they move a 17 per cent greater load than the old engines displaced and with 32 per cent less fuel, and still that is not the whole story. These new engines make this wonderful record in 34 per cent less time than the old engines which is a most important factor in operating efficiency. The addition of these 50 new improved Berkshire engines relieved about 85 engines for other districts and in turn retired less useful engines for sale or scrapping. This, however, is only a good start, for it is contemplated to retire about 7,800 units as follows; locomotives 349, passenger cars 230, freight equipment 6,390, work equipment 915, and marine equipment 5. It appears Mr. Bernet is not disposed to do things on a small scale.

The ultimate economies per year resulting from the plan has been estimated for certain selected items affected as follows:

Saving in wages through use of new power	$ 500,000
In fuel from use of new power, improvement to existing power and scrapping old power	1,100,000
Through cancellation of contracts	800,000
In locomotive repairs	3,100,000
In freight car repairs	1,000,000
In stores department	500,000
Wages	500,000
Reduced cost carrying inventories	100,000
Taking care of cash discounts	100,000
Total	$7,200,000

From the foregoing it would appear that the Erie has effectively placed itself out of range of the sheriff and U. S. marshal and is destined for brighter days in the future.

The foregoing review, with special reference to the Erie as an outstanding example, is indication of what private management can, and actually has accomplished in the way of the physical rehabilitation of our railways as a whole and the restoration of public confidence and good will, which, of course, also includes credit, by which necessary financing can be effected at reasonable interest rates.

It would seem that for the present at least, the professional anti-railway propagandist is no longer in step with the trend of thought of the bulk of the American people.

Intensified Use of Existing Facilities

The mileage of new lines and of new second track built in the United States in 1927 was smaller than in the preceding year, although the year was characterized by heavy expenditures for additions and betterments to roadway and structures. This is in accordance with the railroads' stated policy of securing increased service through the more intensified use of existing facilities.

Railroads in the United States last year built 779 miles of new line and 446 miles of new second track. These figures compare with 1,005 miles of new track and 473 miles of new second track constructed in 1926. Approximately 900 miles of new lines were under construction at the end of 1927, assuring a continuance of construction activities this year.

In only one year since 1914 has the combined mileage constructed by the roads reached a higher total than the 1926 figure. That was in 1916 when 1,098 miles of new lines were opened to traffic.

Expenditures for additional tracks during the first nine months of 1927 amounted to $108,002,000 as compared with $124,084,000 during the same period in 1926. The greater portion of the second track completed last year was built by the larger roads, the longest consecutive mileage being 73.5.

Florida ranks first among the states in the construction of new lines in 1927 with a total of 124 miles. In 1926 railroads in Florida constructed 233 miles. Mississippi holds second place in the construction of new lines last year with a total of 105 miles; Texas is third with 93 miles, although in 1926 it occupied first place with a total of 242 miles.

Yards, engine terminals and shops continued to come in for large expenditures during the year. Bridges, passenger stations, office buildings, and other similar improvements were also pushed to completion during the year. Large expenditures are made for other items such as water stations, water treating plants, etc.

Locomotive and car installations were fewer in 1927 than during 1926. Comparing the first eleven months of each year, the aggregates were 1,820 locomotives in 1927, and 2,193 in 1926. Corresponding totals for freight cars were 67,985 in 1927 and 92,368 in 1926. Passenger car installations for nine months aggregate 1,851 units in 1927, and 2,260 in 1926.

Statistics of unfilled orders for new equipment showed a marked reduction in 1927.

The mileage of lines abandoned in the United States in 1927 again showed a decrease under the preceding year, the total of 282 miles comparing with 457 miles in 1926, and 606 miles in 1925.

Construction of new lines in Canada totaled 310 miles, 30 miles short of the 1926 figure. As in the preceding year, the greater portion of this mileage consisted of branches or extensions of branches in the western provinces.

Power Rail Car Fuels of the Future*

By E. E. Wanamaker, Electrical Engineer, Chicago Rock Island & Pacific

Only a few years ago many wel informed experts predicted that a gasoline famine would occur, at least insofar as economic and reasonable costs were concerned, prior to or by 1927. Naturally the predictions were based on the knowledge then available, but new fields were discovered and in spite of a constantly increasing demand, we today have a plentiful supply at an economic delivered selling price. With all data and information now on hand, we might at this time again predict famine, at least insofar as petroleum from the ground is concerned. It is possible that this anticipated famine would not be due to the fact that there was no petroleum left in the ground, but because the location of such petroleum as was left in the ground, would result in high transportation cost, and in turn a high selling cost, at least in some sections.

In order to allay any uneasiness on the part of those who invest in internal combustion engine equipment, especially the railroad for motive power to be used in handling light traffic, etc., it is desirable to outline how a fuel supply might be insured after a fashion. The most natural line of development, and, at the same time the easiest, would be first, to follow the best methods of utilization and conservation of fuel as obtained from the present natural source of supply; next, development of fuels by distillation of oil shales, coal, organic or plant growth, etc.

Probable Demand for Internal Combustion Engine Fuel

In all probability the demand for automobile fuel will increase, likewise for busses and for trucks. There is an increasing demand for fuel for gasoline, oil, semi-Diesel and Diesel engines used in industrial, agricultural, railway and marine service. Just what or how much the demand will be depends largely on the fuel economics of the engines as designed by the builders. The demand for air craft fuel will, it seems, increase at a rapid rate. Indeed, more than one authority has forecast in ultimate demand that will be equal to that of the automobile.

Liquid fuels for any purpose other than use in internal combustion engines and ships of war are not an actual necessity, but lubricants for operating all kinds of machinery are essential. Hence the demand for such must be considered in any study relative to rail car fuel. In this connection, it might be well to refer to the ultimate value of lubricating oil reclamation and its probable effect on the fuel supply.

The crank case method of lubricating internal combustion engines, using the oil over and over again causes the oil to be in actual practice a cleanser as well as a lubricant. It is therefore possible, by draining it frequently from the crank case, reclaiming and thus using it over and over again, to keep the engine thoroughly clean as well as thoroughly lubricated and promote long engine life.

Several companies have developed and placed on the market plants for such reclamation, most of them consisting essentially of an automatically controlled distillation, separation and filtration equipment.

It has been demonstrated in the case of some distillate engines that the crank case oil should be changed on a 500-mile basis. However, since the actual runs and terminals do not always check out for such a change, the costs were compiled on a 300-mile basis. Experience with the 500-mile change, however, indicates that the oil itself was as good as ever at that time and when put through the reclaimer, removing water, distillate,, foreign matter and possibly some light ends of the oil, gave even better service than when new. On the basis of 75 per cent of the original oil reclaimed, the process, it seems, can be repeated over and over again. In other words, on this short mileage the lubricating value of the oil is never lost.

The indications are that if motorized rail equipment can be built in which the first cost, and the maintenance, fuel and lubrication costs are not too high, practically all of the light railway traffic can be motorized to the ultimate benefit not only of the railways but of the public they serve.

Therefore, in making a study of rail car fuels it becomes necessary first to analyze the equipment or engines which might meet the economic and service requirements.

But little will be said about small engines of 100 hp. or less since there will in all probability be few of them aand it is engines or cars of 200 hp. or more to which consideration will be given. It would seem that individual engines may be required of at least 400 hp., dual 800 hp. In other words, the range may be 200 to 800 hp. for light rail traffic, including in this range power for 50-ton single motor cars up to 300-ton trains in local passenger service with schedules of from 25 to 30 miles per hour, industry switchers and locomotives for switching other than heavy classification yards, light local and mixed train service on branch or light traffic lines.

Rail Car Fuels Available

Bearing in mind what the producers are accomplishing in the way of increased distillation efficiency of petroleum and the possibilities of fuel oil shales, coal, etc., with alcohol as a diluent for heavy oils and possibly more effectively used, there are available today the following liquid fuels for rail car operation:

Gasoline	Fuel oils	
Kerosene	Benzol	Distillate
Light Diesel oils		Heavy Diesel oils

This list is readily shortened since benzol is in most cases too expensive; kerosene is but little if any cheaper than gasoline on account of the growing demand for kitchen oil stoves, etc. Fuel oil so far has been successfully burned only in large slow-moving stationary and marine Diesel engines. This leaves available gasoline, distillate, light Diesel and Heavy Diesel oil.

This distillate engine is primarily a well designed and well built gasoline engine, with a specially designed carburetor for better atomizing and mixing the fuel; slightly lower compression and minor changes in cylinder head design.

The light Diesel oils are suitable for use in high compression solid injection engines when admitted to each cylinder at a fixed time near the top of the compression stroke by a motor driven pump which delivers it to the atomizing injection valves at a pressure of from 3,000 to 10,000 lb. per sq. in.

Heavy Diesel oil is suitable for use in air injection or true Diesel engines which on account of weight and low crank shaft speeds are hardly yet adapted to rail car service as viewed from the standpoint of an operating railroad man.

The gasoline engines as built today are undergoing some changes, the nature of which depends on the service in which they are to be used. In the automobile field the trend is toward higher compression engines in an endeavor to increase capacity and efficiency and decrease

*Abstract from a paper read before the Society of Automotive Engineers.

weight and cost of engine. This will probably result in forcing a higher grade of gasoline at a higher cost, especially so since the automobile engine aparently requires a higher volatile fuel in order to provide the flexibility and indifference to temperature changes due to weather and irregular operation, that the automobile driving public seem to demand.

Air craft engines require a light gasoline with no heavy ends in order that they may obtain thermal efficiency and therefore economy in weight of fuel carried rather than economy in cost of fuel.

Liquid Fuel Specifications

Rail car gasoline engines, large busses, trucks, industrial engines, etc., do not require such a high grade gasoline, hence in referring to gasoline fuel and to distillate fuel, we will consider them as those fuels that conform to the following brief specifications:

No. 1 gasoline is suitable for gasoline rail cars and low compression automobile bus, truck and industrial engines. The No. 2 gasoline is suitable for high compression automobile and heavy air craft but not for war or stunt air craft which for the present at least seem to require a still higher grade.

Gasoline

	No. 1	No. 2
Color (Saybolt scale)	16	25
Doctor	Neg	Neg.
Corrosion test	(Neg. Immersion)	(Neg. Evaporation)
Distillation range:		
Not less than 5 per cent over at	180 deg. F.	167 deg. F.
Not less than 50 per cent over at	284 deg. F.	221 deg. F.
Not less than 90 per cent over at	392 deg. F.	311 deg. G.
End point not over	437 deg. F.	374 deg. F.
Sulphur—not over	0.10 per cent	0.10 per cent

The specification for distillate quoted has governed the selection of fuel for distillate burning rail cars for some time.

Distillate

1. The distillate shall be free from water or suspended matter.
2. Color is unimportant.
3. Doctor test negative.
4. Viscosity not higher than 34 seconds Saybolt Universal at 100 deg. F.
5. Distillation Range:

Not less than 5 per cent	over at 375 deg. F.
20 per cent	over at 425 deg. F.
50 per cent	over at 450 deg. F.
90 per cent	over at 550 deg. F.
End Point	over at 600 deg. F.

6. At least 95 per cent shall be recovered after distillation.
7. The residue left in the flask after distillation shall not show an acid reaction.
8. Sulphur shall not be over 0.30 per cent.

Stationary and marine plants of large size necessitate expensive and heavy Diesel engines in order to obtain the utmost in cost economy both by frugality in fuel consumption and by use of fuel at moderate cost, such equipment not being adaptable to rail service.

It seems that rail cars or motorized rail equipment using internal combustion engines, occupy a field intermediate between that of the automobile, bus, truck, etc., and the stationary or marine engine. The distillate fuel and engine according to some recent commercial service tests, seems to give sufficient flexibility under rail car operation conditions, particularly where modern and efficient electric transmissions are used, and at the same time approaches the low cost of the fuels used by stationary and marine engines.

Motorized rail equipment of the capacity mentioned heretofore requires a comparatively light weight engine, compact, flexible in operation, with speed and design conducive to long life, inexpensive to maintain, able to stand all weather conditions, easy to cool with limited water supply, efficient in fuel consumption and cost, also lubrication, and last but not least, with comparatively low first cost to keep down excessive fixed charges. It is in an endeavor to meet these rather difficult requirements that much work has been done to develop such an engine and fuel supply for it.

Distillate an Economic Fuel

Distillate seems to come from an economic point in the cracking process. In the pressure distillation or cracking process by which gasoline is made from the so-called gas oils, a by-product somewhat similar to the kerosene obtained from the straight distillation of crude petroleum is developed.

This distillate or pressure distillation kerosene is difficult to crack into gasoline, does not burn on a wick without smoking and when burned in home heating furnaces has a tendency to turn the window curtains somewhat yellow.

It is made in considerable quantities whenever gasoline is cracked from gas oils and it would seem more profitable for the refiner to sell it as distillate at a distillate price rather than attempt to crack it by any known method or process, or refine it to a point where it could be used as a substitute for kerosene for any of the more common uses of that product.

Some recent experience in commercial service indicates that there is an economic co-ordination of the distillate engine and distillate fuel together with suitable lubricating oil reclamation peculiarly fitting rail car service using engines in the capacity range referred to herein. Some of the reasons for this conclusion are:

First, regardless of the initial source of internal combustion engine fuel supply, it is most reasonable to assume that the differential between gasoline and distillate will increase with any increases in gasoline cost. In other words, the differential may easily increase from one, two, three, or four cents as the case may be, to ten cents.

Second, distillate lends itself to safe and easy storage with but little evaporation loss or liability to explosion, as is the case with gasoline. It can, therefore, be easily purchased and handled in tank car lots.

Third, distillate is not nearly so liable to be stolen as is gasoline.

Fourth, it is safer than gasoline when carried on rail cars or motorized rail equipments in any considerable quantity, and economy necessitates carrying several hundred gallons on the larger motor cars.

Firth, distillate properly carbureted is a smooth burning fuel and where heavy loads are handled for long periods this is a very desirable feature.

Six, the first cost, operating and maintenance, cost of distillate engines and fuel, flexibility and their reliability for capacities ranging from 200 to say at this time 500 hp. capacity, all tend to balance out a net economy in rail car service, even now in this flush period of gasoline supply with a promise of offering a better net in the future as compared with gasoline and Diesel engines.

The following figures may offer some suggestions as to what we may look for in the future.

Distillate costs are, considering all factors, now running about four cents under gasoline costs, delivered into rail car tanks for service.

In the case in hand, with distillate at six cents and gasoline at 10 cents a gal., lubricating oil at 50 cents, and a lubricating oil reclaiming plant used, we find that a 90-ton two-car motor train with one 275-hp. engine operating 300 miles per day, 300 days per year, will consume 12 gal. of lubricating oil per 300 miles, consisting of:

3 gal. of new oil at $0.50	$1.50
9 gal. of reclaimed oil at $0.10	.90
Total	$2.40
Average cost per gal	.20
Operating cost using distillate fuel:	
Fuel	3.53 cents per mile
Oil	0.8 cents per mile
Total	4.33 cents per mile

Operating cost using gasoline fuel:
(15 gal. of lub. oil required for 1,500 miles)

Fuel	5.9 cents per mile
Oil	0.5 cents per mile
Total	6.4 cents per mile

The saving in favor of distillate and reclaimed oil equals 2.07 cents per mile, or $1,863 per year. This is a saving of $465.75 per year for each cent differential in price between distillate and gasoline. In case of a dual power plant the saving is doubled.

Looking ahead to a probable differential of 10 cents per gal., the saving in the case of the single unit 90-ton train would be $46,575 in 10 years, or more than the cost of the motor car. In the case of the dual unit 180-ton train, the saving would be $93,000, a great deal more than the cost of the car.

It is such figures as these that are apt to make one look with some favor and an investigatory mind toward distillate engines and distillate fuels insofar, at least, as rail cars are concerned.

New Three-Power Locomotive

A new battery-oil-electric locomotive, carrying its own power plant and the first of its kind ever built, was recently tested in New York by the New York Central Railroad for which it was constructed for service in freight yards which are not completely electrified and where part of the time it is required to operate through city streets.

As this new locomotive will be required to operate at times over tracks which are electrified, third rail shoes are provided, together with an overhead collector. This permits the operation of the traction motors from external sources of supply when in electrified districts.

The new locomotive, which weighs 128 tons in working order, is a product of designs by the New York Central's electrical engineering department working in combination with the General Electric Company and the Electric Storage Battery Company, and was built by the American Locomotive Company.

When the locomotive is operating in the non-electrified sections, the power is furnished by an Exide storage battery of 218 cells weighing 17 tons, one of the largest batteries ever used for locomotive service. The battery is charged by a 300 horsepower Ingersoll-Rand oil engine, connected directly to a 200 kilowatt General Electric generator. This is so designed that, if it is operated at the same time that power is being supplied to the traction motors, it will divide the load with the storage battery in periods of heavy output without overloading the engine and will return automatically to charging the battery as soon as the load has decreased. The battery supplies the surges of power required in switching service when a locomotive must respond quickly.

The locomotive, which is 46 feet, eight inches long over the couplers, is a swivel truck type with a cab in three sections, the batteries being carried in the end sections and the oil engine in the central section. The batteries are arranged in tiers. The central section of the cab, in addition to the power plant and control apparatus, has two small operating compartments for the enginemen. There are doors giving access to each operating compartment from the outside and to the power plant from the operating compartments.

In the roof of the central compartment, directly above the oil engine, is a hatch permitting the removal of the engine if necessary. The locomotive is equipped with four General Electric, 600-volt, single-geared traction motors each of 415 horsepower. Control is non-automatic with individual electro-pneumatically operated contactors and the locomotive may be operated from either end.

There are four methods of operation: from the storage batteries alone; from the storage batteries and engine generator together; from the third rail, and from an overhead collector. As the change-over from external to internal power supply, or vice versa, occurs automatically, indicating lights are provided in the enginemen's cab to show under which condition of operation the equipment is running.

New Battery-Oil-Electric Locomotive of the New York Central Lines

The locomotive has unusually complete metering equipment in order to assist the engineers in studying its utility for service and determining what, if any, modifications should be made for future locomotives of this type.

Fuel tanks having a storage capacity of 200 gallons of oil are provided. These are sufficient to operate the engine at full load for about ten hours. The engine is run at constant speed under control of a governor.

The locomotive will be tested in actual operation in the West Side freight yards of the New York Central Railroad in New York.

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Heating Passenger Trains

Every railway system when it enlarges and improves its motive power to permit consolidated train movements, force serious train-heating problems. It will be remembered that it was in 1912 that the American Railway Association adopted the 2-inch steam heat train line with 1½-inch end valve opening as standard. In 1903 the 1⅝-inch hose with 1½-inch hose nipple and gasket was adopted.

There are two problems in heating passenger trains, steam supply and its utilization.

Condensation occurs less rapidly in pipes conveying superheated steam than in those carrying saturated steam. The thermal conductivity of superheated steam is much lower than that of saturated steam.

The only real value of superheated steam for train heat is to keep it in the train line, but this cannot be done without getting so much that it must enter the piping inside of cars on a long train at a high pressure if any is to be expected well back in the train line.

The great question or problem is that of getting the proper volume of steam and keeping the pressure as low as possible. A vacuum pump may be advantageously used on the longer trains.

The question of drop in pressure in steam pipes is well brought out in Harding and Willards work on Heating and Ventilating.

In treating pressure drop in pipes under their formula, it works out that with 120 pounds at the rear of the tender and a 2-inch train line and fittings, including 2-inch hose, there is a 12-pound drop on 10 cars, 41 pounds drop on 15 cars and 118 pounds drop on the tenth car of a 20-car train.

The value of thermostatic control is that a large part of time cars are idle and it is then that they are usually hottest. In the controversy between one of our large railway systems and Pullman Company some years ago, as to the cost of heating lay-over cars, it was finally agreed that a charge of 75 cents per car day be made. Most coach yard boiler plants are deficient and any saving there is valuable.

One of the greatest needs is to reduce friction in train lines which is causing the necessity for such high pressure in steam train line, causing hose failures by the thousands, poor heating and generally bad results.

It would seem that the 2-inch hose couplers, and valves, gaskets, etc., were at least a vital need. Engines will haul 15 to 20 cars, but the heating train line is a badly mooted question at present. The whole heating problem, as it relates to our modern combined passenger trains of 10 to 15 or 20 cars, calls for a complete survey with a view of such improvements as may be found necessary to properly meet changed conditions.

In making a study of this question it seems an opportune time to also work out and show the subdivision of fuel used, and the steam consumed from specific locomotive boilers for the following purposes:

Steam cylinders for tractive power;
Air compressors;
Steam heating trains of the different sizes and service;
Electric headlight;
Lighting;
Booster;
Miscellaneous.

The foregoing tentative subdivision of fuel and steam charges to be made to the different uses that constitute the total drain on a locomotive boiler, will, no doubt, result in bringing out much interesting data. This in turn may result in still farther research, with a view of improvements that make for higher efficiency and greater economy.

This study might properly be extended to the question of the relative cost to move or propel suburban trains and the cost to heat and light them with either steam or electricity as a prime mover.

Research a Fundamental Necessity

In engineering research the results rest entirely with the man. Some standard equipment and commercial devices are employed but at every turn the condition is met that development and discovery is dependent on the human element.

In considering the qualifications of a research engineer, we are confronted with the question of initiative, a basic quality in every line of human endeavor. Then he must have ability and focus his attention on the selection of tasks which have been weighed both as to their economic and commercial value. We are chiefly concerned with whether a new idea will add more service life to the product, and in preventing break-downs or failure of some piece of equipment enhance the value of the service operation.

The life of man is so comparatively short that the best trained and greatest engineer, is still a student at the end of life's span. The following generations of the profession must of necessity go over practically the same route road and training as their predecessors. So that, in the last analysis the life of the scientist, engineer, scholar, artisan and tradesman is largely one of continuous research, from which we have confirmation of or improvement upon old ideas and the discovery of new ones.

Engineering in its last analysis consists of "the application of nature's forces to the use of man," and he who can or does excell in that accomplishment is by such token a good engineer. An active useful life is largely made up of search, search, more search, then re-search.

Higher Steam Pressures

Increased steam pressures seem to be in line with modern engineering progress. Elsewhere in this issue will be found an article on higher steam pressures, which it is hoped may result in renewed activity on the part of those interested in this most important subject.

Aside from the well known instances of high steam pressures on modern locomotives, ranging as it does from 300 to over 800 lbs., it is interesting to note the action of Holland engineers in the rebuilding of a large power plant at the Werkspoor Works in Amsterdam. The steam pressure formerly used of 160 lbs., was increased to 570 lbs., or about 256 per cent. When we learn of such drastic action, we can with due conservatism ask why some of these changes have been so long deferred, rather than are there well justified engineering hazards involved.

It should be understood, that we do not either advocate the change from the low pressures or present prevailing practice, to 400, 600, 800 or 900 lbs. of steam for locomotives, or offer any criticism of those who are responsible for these pressures. We do feel, however, that available data on the subject shows not alone the theoretic possibilities and demonstrated practical value of higher pressures, but indicates a wonderfully inviting field for economy in most all prime movers. The present is a most opportune time for a decided move in the direction.

Why procrastinate or take so many bites at one cherry.

Motor Transport Division American Railway Association

The American Railway Association that is doing such excellent work for the railways and the entire country, has added a new member to its already distinguished family.

The Motor Transport Division will, we predict, function to the mutual benefit of the various interest that must of necessity have a concern in its existence or the problems to be considered by this Division.

Some months ago we presented through the columns of Railway and Locomotive Engineering a review of the wonderful progress in aerial transportation both in this country and abroad which was intended not only as a matter of interesting news to our readers but as a reminder to those engaged or interested in transportation as to possible and probable "coming events" in the field of transportation.

We do not intend to convey the idea that aerial transportation has yet reached that stage of development which warrants its activities to be considered as equal to that of motor transportation, particularly from a financial standpoint, but we do feel that preliminary steps should now be taken looking toward the time when it will equal, if not far exceed, the motor industry.

We may anticipate the aerial transport division of the A. R. A. which in all probability will be an actuality long before some of our wisest prophets may reluctantly concede its possibilities.

Valuation Work Has Cost 130 Million Dollars

The work of valuing the railway properties of the country "came about very largely as a political movement to find out whether the railroads were overcapitalized," recently testified Ernest I. Lewis, Interstate Commerce Commissioner, before the House Committee on Appropriations. The Committee was meeting for the purpose of voting funds for continuing the Commission's valuation work.

"But when one goes into the history of valuation," Commissioner Lewis stated in his testimony, "he finds its basic foundation far deeper and more substantial than that.

"Its origin really lies in the rule of constitutional law laid down by the Supreme Court in the Smyth v. Ames case in which the United States Supreme Court said:

" 'We hold, however, that the basis of all calculations as to the reasonableness of rates to be charged by a corporation maintaining a highway under legislative sanction must be the fair value of the property being used by it for the convenience of the public.' "

An indication of the cost to the government of valuation work is shown by Commisisoner Lewis's description of the steady increase of employes required to complete the work. At the end of 1925 the number of people on the Commission's valuation staff was 528, Commissioner Lewis said, and at the end of 1927 it was 614. The estimate for 1929 covers 671 employes. The Commission had a peak of almost 1,700 employees in 1918, during the war period.

The revision of the underlying tentative valuation reports which the Commission has handed down will require about 7 million 300 thousand dollars, according to Commissioner Lewis. This is in addition to the regular expenses for the work.

When the Valuation Act was passed 15 years ago, the late Senator LaFollete, sponsor of the law, estimated that it would cost the government $2,400,000 to complete the work, and the railways an equal amount, a total of around 5 million dollars. The Interstate Commerce Commission, just after the law was passed, estimated that it would cost the government from 10 to 15 million dollars.

Up to date it has cost the government more than 30 million dollars and the railroads more than 100 million dollars, a total in excess of 130 million dollars.

Some Observations on Railway Operation

By ARTHUR CURRAN

A survey of what is being done to cut operating costs on American railways would reveal many interesting facts if the men who are making these economies possible had the time to set down, in a comprehensive manner, the results of their labors. As it is, the available reports are necessarily but fragmentary notes of scattered achievements in a variety of directions. Nevertheless, there are one or two points which may be touched upon at this time.

In the first place, a reduction in the amount of double-heading has been accomplished, with further gains in this direction in prospect. Of course, there are certain regions in which the use of two or more engines will be necessary to move the traffic; but the number of such localities is likely to decrease as more powerful locomotives are introduced, or re-alignments of track improve operating conditions.

Curiously enough, a very prominent road at one time did a great deal of double-heading on low-grade divisions; though for what reason must remain one of the mysteries of railroad history. On this road, it was no uncommon sight to see two big Pacific type engines hauling a passenger train which should have been well within the capacity of either of them. As the tractive effort of these engines ranged from 32,000 to 38,000 lbs., the above statement is scarcely overdrawn. Certainly, a combined tractive effort of 70,000 lbs. was rather ambitious, under the circumstances! Then, too, there were two engine-crews to be paid; and coal, oil and water to be supplied to an extra engine for which, so far as a practical man could see, there was not the slightest necessity. That fad has since worn out!

In the second place, much good has resulted from the establishment of more exacting standards in the maintenance of freight cars. The amount of expense, delay and labor occasioned by bad-order cars in past years would go far toward neutralizing the benefits of more efficient motive power if such handicaps were allowed today. Broken draw-bars may make trouble; but the days when cars used to be offered at transfer-points with an assortment of their removable parts decorating the ballast of the road whence they came and with their journal-packing as dry as a chip, are now, happily in that "golden past" of which we sometimes read but which we would not have back at any price!

When it is realized that a fallen brake-beam may precipitate a "pile-up" that will "lay out" a division, it must be clear that strict standards are abundantly justified. In this connection, however, it is important to remember that some "accidents" have a rather "fishy" flavor. Railroad "Dicks" will know what this means, and without any trouble!

Ordinarily, the percentage of safety on railroads will stand at a very high figure—that is, if it is allowed to do so. Recent occurrences show, however, that a close watch must be kept for mentally deficient scamps who tamper with railroad property at every opportunity. Wrecks which are caused by such persons are not properly chargeable to the railroads, but they help to create public apprehension and thereby weaken faith in railroad management.

The use of one type of locomotive over all divisions of a long run has much to recommend it; since maintenance is thereby simplified and schedules are stabilized. This applies, in particular, to passenger service.

The draw-back to such an arrangement, however, is found in the arbitrary "release" of perfectly good and serviceable power for which it may not be easy to find suitable employment elsewhere. An apparent economy may, therefore, carry with it undesirable reactions; unless, of course, the displaced power is undeniably obsolete.

Speeding up service on mountainous divisions and handling increased train-loads on low-grade divisions in sparsely settled districts constitute the two chief functions of exceptionally large locomotives.

In thickly populated regions, however, the demand is for frequency of service, rather than the operation of tremendous limiteds at infrequent intervals. In view of this, it is difficult to escape the conclusion that the abandonment of the very useful Pacific type would be a serious mistake. Certainly, the starting power and steaming capacity of this type are very high for the total weight, initial cost and expenditure for maintenance. Furthermore, there are few through passenger trains in this country whose "consist" runs much above 10 or 12 cars. On low-grade divisions, such trains are easily within the capacity of a well-designed Pacific type engine at almost any time of the year. Storms which would block this type would furnish plenty of amusement for any other!

As showing what it took to get an eleven-car train over the mountain west of Altoona, the accompanying photograph of Train No. 13 may be of interest. Both engines are of the well-known class K-4-S, the standard Pacific of the Pennsylvania Railroad.

As is also well-known, the road has since adopted the Mountain type; but no one has heard anything about an intention to scrap the Pacific engines! The P. R. R. is much too smart to do anything like that.

The entire question of the exceptionally large locomotive is one requiring very careful study. Fortunately for this country, railroad managements are free to solve their own problems without bureaucratic interference. Too much enthusiasm is quite as bad as too little!

So far as freight service is concerned, the heaviest trains which draft-gear and brake-rigging will stand are the "order of the day." There is a noticeable tendency

Double Heading on the Pennsylvania Railroad West of Altoona, Pa.

to increase the speed of such trains, and this should make friends for the railroads. At the same time, very great care will be needed in the maintenance of freight equipment if this practice gains in favor. Talk of "passenger speed" on low-grade lines will be all right if "passenger inspection" goes with it! And, in that case, it is going to take some lively work at division terminals to avoid losing more time than the big engines can save.

However, if the job is tackled, it will be done. For, that is the way of American railroads!

New Records Made in Freight Service

For the eleven months ended with November, 1927, the Class 1 railroads made the best record for any similar period since 1920 in the following items of freight service: gross and net trainload; gross ton-miles per train hour (excluding locomotive); car-miles per car-day; number of cars per train (including caboose), and pounds of coal per 1,000 gross ton-miles.

These facts are contained in a report just issued by the Bureau of Statistics of the Interstate Commerce Commission.

As to net ton-miles per mile of road per day, net ton-miles per car-day, average carload, and per cent of loaded to total cars, the record of 1927 was exceeded in one or more of the preceding years.

The average gross trainload (excluding locomotive) for the first eleven months of 1927 was 1,790 tons and the net train-load was 783 tons. The gross ton-miles per train hour (excluding locomotive) was 22,023; car-miles per car-day totaled 30.7; cars per train (including caboose) were 46.7, and pounds of coal per 1,000 gross ton-miles (including locomotive) stood at 129.

The operating efficiency of the railways of the United States reached is a new high level in 1927. Many of the factors of efficiency broke all records, while all the others compared favorably with any other year.

These high levels attained by the railways in 1927, as already pointed out, were another forward step in the program of progressive improvement in railway operation and efficiency which has been under way since the beginning of 1923.

New Eight-Wheel Switchers of the Boston & Maine

Have Tractive Power of 56,800 Pounds and are Equipped With Feedwater Heaters

Ten eight-wheel switching locomotives, designed for a boiler pressure of 250 lb. and equipped with feedwater heaters, articulated main rods and snow melting devices, have been received from the Baldwin Locomotive Works and put in service by the Boston & Maine at various yards to further expedite freight service and to effect new economies in operation. These locomotives have released an equal number of less modern eight-wheel switchers of lighter tractive capacity for assignment to other yards, this reassignment, in the end, retiring several of the least modern and effective yard locomotives.

The assignments were made to get the utmost benefit out of the increased tractive force and the fuel saving devices on the engines. The Boston & Maine expects to realize economies both from the latest improvements with which these locomotives are equipped, and from the ability of each unit to do a greater amount of work in a given time.

These locomotives are designed for operation on grades up to 1½ per cent and curves as sharp as 19 deg. With a weight of 244,800 lb. on the drivers, the engines develop a starting tractive force of 56,800 lb., the ratio of adhesion thus being 4.3. Such a ratio permits the development of full tractive force without slipping under average rail conditions.

These locomotives have straight top boilers with wide fireboxes. The working pressure is 250 lb. On eight of the locomotives, the brick arch is supported on four tubes; while on the remaining two, the arch is carried on two tubes and two Nicholson siphons. A type A superheater is applied, and the tubes and flues are welded into the back tube sheet. Flexible staybolts are applied in the breaking zones.

The boiler accessories include a feedwater heater of the Coffin type with the feed pump placed on the left side at the rear end of the locomotive. On the feed pump delivery line is a fitting for attaching 50 ft. of 2-in. fire hose, which is carried on each engine. The feedwater heater is located at the front of and flush with the outside shell of the smokebox.

The ash pan is of cast steel and is fitted with hot water piping for washing the ashes off the side slopes.

These locomotives are designed for limited cut-off. The piston valves are 12 in. in diameter and have a maximum travel of 8½ in. and a lead of ⅛ in. The baker valve gear is applied, and is controlled by a Ragonnet type E reverse mechanism.

Special materials are largely used for the machinery parts with a view of insuring ample strength for severe service, with minimum weight. The piston heads and the piston valve bodies and followers are of electric cast steel. Chrome-vanadium alloy steel, quenched and tempered, is used for the piston rods. The crank pins are of chrome-vanadium normalized steel and are hollow bored. The main driving axle and the main and side rods are of carbon-vanadium normalized steel. The axle is hollow-bored.

A forked main rod provides direct connection to the rear wheel crank, transmitting a portion of the piston thrust directly to the rear wheel, thus relieving some of the strain on the main crank pins and main journals. Main and side rod bushings are of the floating type of decrease wear.

The steam turret is arranged to permit all valve operating handles to be placed on one control board in the cab. All of the dial gages are similarly localized on one board for ready reference.

Each of the locomotives is equipped with snow melting devices which are located below and in back of the front

New Eight-Wheel Switch Engine of the Boston & Maine—Built by the Baldwin Locomotive Works

Type of locomotive	0-8-0
Service	Switching
Cylinders, diameter and stroke	23 in. by 28 in.
Valve gear, type	Baker
Valves, piston type, size	12 in.
Maximum travel	8½ in.
Outside lap	2⅝ in.
Exhaust clearance	⅛ in.
Cut-off in full gear, per cent	60
Weights in working order:	
On drivers	244,800 lb.
Tender	176,200 lb.
Wheel bases:	
Driving	15 ft.
Rigid	15 ft.
Total engine	15 ft.
Total engine and tender	54 ft. 10½ in.
Wheels, diameter outside tires:	
Driving	51 in.
Journals, diameter and length:	
Driving, main	11½ in. by 12 in.
Driving, others	10 in. by 12 in.
Boiler:	
Type	Straight top
Steam pressure	250 lb.
Fuel kind	Bituminous
Firebox, length and width	102⅛ in. by 66¼ in.
Height mud ring to crown sheet, back	73½ in.
Height mud ring to crown sheet, front	75½ in.
Arch tubes, number	4
Tubes, number and diameter	36—5½ in.
Flues, number and diameter	226—2 in.
Length over tube sheets	15 ft.
Grate area	47 sq. ft.
Heating surfaces:	
Firebox	190 sq. ft.
Arch tubes	24 sq. ft.
Flues and tubes	2,538 sq. ft.
Total evaporative	2,752 sq. ft.
Superheating	608 sq. ft.
Comb. evaporating and superheating	2,360 sq. ft.
Special equipment:	
Brick arch	Yes
Superheater	Type A
Feedwater heater	Coffin
Tender:	
Style	Rectangular
Water capacity	10,000 gal.
Fuel capacity	13 tons

bumper beam. These devices consist of live steam nozzles on four cylindrical drums, one on either side of each rail.

Flanged tires are used on all the wheels of these locomotives. Flange oilers are applied to the front and rear drivers. The transverse distance between tire faces is 1/16 in. less on these wheels than on the main and intermediate pairs. The cylinders are oiled by a force feed lubricator, driven from the valve motion.

The tender is carried on rolled steel wheels, and has a Commonwealth cast steel frame. The tank has a straight top and side walls of the fuel space curve inward, following the contour of the cab roof, in order to give the enginemen the best possible view when backing up.

Details of dimensions and weights are given on page 49.

High Steam Pressure

Since high steam pressures are being employed in the railway field, why restrict the economic advantages to a few locomotives? Why not employ high steam pressures for motor cars, wrecking cranes, steam shovels, pile drivers, switching engines, locomotive cranes, etc.

A description of the locomotive "Horatio Allen," with a steam pressure of 350 pounds appeared in the January, 1925, issue of *Railway and Locomotive Engineering*. At that time the high pressure employed was considered excessive by some engineers. In the February, 1927, number we gave a detailed description of the "John B. Jervis," a locomotive employing a steam pressure of 400 pounds. Both of these engines were built for and are in regular service on the Delaware & Hudson Company. They were designed by John E. Muhlfeld, consulting engineer for that company, who has been for many years a constant advocate of the use of higher steam pressures in locomotives.

In *Railway and Locomotive Engineering* for March, 1926, there appeared some details of a locomotive in Germany that carries two different steam pressures, 853 and 200 pounds, the exhaust from the use of the higher pressure being combined with the lower pressure.

In view of the foregoing developments that are now in successful use, let us tentatively consider 600 to 1,000 pounds per square inch working boiler pressure and using oil fuel under the boiler, rather than in an internal combination engine.

Use a self-regulating power plant.

Use superheated steam at less than 200 deg. superheat.

High pressure units occupying only small space could be designed and perhaps small direct acting engines operating on each axle (8-cylinder single acting poppet valve uniflow engines).

The oil from the condensate could be separated and re-used.

Engines working with a condenser neither exhaust to the atmosphere nor through any part of the combustion system, thus eliminating the entrance of foreign matter into the engines from that source. The engines could be enclosed for protection from dust and dirt, no smoke or steam could escape under this system and no sparks. Stops for water would not be necessary as it could be carried in a properly designed tubular boiler in amount equivalent to that now needed for cooling the ordinary internal combustion engine of equivalent power. A small quantity need only be replaced each day.

An auxiliary engine would operate a generator to supply current for head-light, interior lighting, blower motor, feed water and oil pump motors, oil separator, condenser fans and air compressors.

It may be mentioned that the Erie steam shovel people, in common with others, went to gear-driven internal combustion engine shovel design for city use. However, they found it necessary to substitute a gas-driven compressor to operate the crowding mechanism by a compressed air engine rather than through gears. The rather favorable attitude of the trade toward this character of improvement seemed to serve as an endorsement of the manufacturer's policy in this matter.

Steam operation as compared with internal combustion engines, operating a motive power unit either directly or through an electric generator and motors provides (1) simplicity in operation, (2) economy in fuel, (3) the unit may be driven in either direction, (4) reliability in operation, (5) economy in mechanical maintenance, (6) smoothness of running, (7) comfort in seating, lighting, heating and ventilation, (8) capacity to maintain required schedules and (9) flexibility of output.

The proposal for a smokeless, sparkless and continuous running steam unit, starting under load or adverse grades would provide a prime mover for work on busses and motor boats, and it also contemplates heating the units involved from exhaust steam.

The foregoing tentative suggestions are offered, not as a criticism of present conditions or individuals, or as specifications for new equipment, but with the thought that possibly among the several suggestions there may be some that may prove helpful to those who feel there is room for improvement in any of the various engineering lines to which they may apply.

Train Radio Given Public Test

A successful public test of the General Electric method of radio communication on trains was made recently on a 110-car freight train running from Selkirk Yards, New York, to Utica over the New York Central Lines. A large group of railroad officials and radio engineers was carried, and constant communication was maintained between the caboose and the locomotive cab.

Over the 95-mile trip both conductor and engineman, though separated by more than a mile of intervening freight cars, were in oral communication at will, and without any aerial interruption whatever, or interference with their customary duties. Both these factors were taken as an indication by observers of the great economic value of the radio equipment in speeding up freight train movements because of its dependability and simplicity.

During the trial trip communication was established between conductor and engineman on the moving train, and the signal tower at South Schenectady, when the train was eight miles away.

The communication is afforded by small, compact, low-power radio transmitters and receivers operating in the 109-130 meter band. At this wave-length the equipment on the train demonstrated that its use set up no interference with outside broadcasting or public radio reception, and in turn it was noted that other broadcasting service in no way interfered with the train communication.

One of the principal features noted by the observers aboard the train was the simple and easy manner in which communication was interchanged. Pushing a button in the caboose caused a piercing whistle to issue from the powerful loud speaker located in the cab of the locomotive over the engineman's head.

The engineman had only to pick up a familiar type of hand telephone to establish the connection, and the conversation between himself and the conductor in the caboose was carried on as easily and fully as clearly as an everyday telephone conversation in the factory, office or home.

This easy method of talking between the extreme ends of a long freight train serves to reduce to a minimum hitherto unavoidable delays in the movement of this class of train. These delays arose because of the distance intervening between the locomotive and the caboose, which limited the carrying on of communication by hand and light signals or the dispatching of messages on foot by members of the crew. All three of these methods were normally slow and have proved for years great consumers of time. In the case of the radio conversations, the communication was instantaneous with all train movements promptly made and at a considerable saving of time as compared with present practices.

By the general use of this radio equipment, the railroad observers pointed out, there would be a material cutting

Engineman Using Microphone of Radio Equipment on New York Central Locomotive

down of delays to freight trains, that result from occasional incidents such as the parting of an airhose, the development of a hot box, or the necessity of setting out cars on sidetracks between terminals.

Another feature of the simplicity in the use of this equipment is that it is adjusted and tuned, to the particular wave length desired, at terminal points. The entire apparatus is then locked up and no attention is required by the train crew during a trip. The starting and stopping of the transmitter is all automatically performed by the simple action of picking up the telephone.

The demonstration of the equipment as witnessed by the railroad officials follows several months of its continuous and satisfactory service in experimental operation.

On this particular trip considerable time was saved at the start of the run. When the customary pusher engine, which is used to assist in starting the train from the yards, arrived, the engineman was promptly advised over the radio that the pusher was ready to go. Quickly in turn the start signal was relayed back by the engineman. When the latter signal was received both engines started at the same time and the train was off immediately. Other routine communication incident to the operation of the train, which would have otherwise required considerable time to relay between the cab and caboose, was speedily carried out on the trip with any delay completely eliminated by the use of the radio equipment.

The equipment used on both locomotive and caboose sets as designed by the General Electric Co. for the New York Central Lines is comparatively of simple structure and compact. On the locomotive a metal box holds the transmitter and receiver. It is made of steel boiler plate, welded together, and is installed on the deck of the tender. It is completely weather-tight, being made of exclude water or other foreign material. The entire assembly is supported by eight springs, and in addition a system of snubbers is provided to prevent excessive oscillation.

The transmitter compartment contains three 50-watt tubes and one 7½-watt tube. Four of the latter size tubes are used in the receiver. The 7½-watt tubes are the standard train control type, the reliability of which has already been proved by extensive use in signal department service. The 50-watt tube is a standard design used for aircraft and marine applications for a number of years.

The power unit for the equipment, which contains the necessary dynamotors, filter condenser, reactors, etc., is also housed in a metal container. Two dynamotors are utilized. The larger one operates only when transmission is taking place, and supplies plate voltage at 1,000 volts, direct-current, to the transmitter. The smaller machine runs at all times when the equipment is on the road and delivers plate voltage and bias voltage for the radio receiver. The use of this small machine permits the elimination of all batteries in the set.

Power on the locomotive is supplied from the headlight generator, no storage batteries being required. On the caboose a standard generator, driven by a belt from the axle, is used to charge a 32-volt storage battery. This battery supplies all the power required for transmitting and receiving. The total amount of power drawn by the equipment when transmitting is approximately 30 amperes at 32 volts, direct current, while in receiving, the current is approximately five amperes. This is the current required by the receiver dynamotor and the receiver filaments.

The loud speaker used in both engine and caboose is of a special type capable of producing a maximum amount of voice volume, and designed specially for these train sets. One loud speaker is bolted to the roof of the cab over the engineman's head. The other is mounted to the roof inside of the caboose. The opening for the sound is protected by means of a heavy wire screen so that an accidental blow will not damage the sound producing unit inside. Excellent speech quality is obtained from this loud speaker, obviating the use of a head-set.

The antenna on the locomotive consists of a brass pipe mounted around the water tank of the tender. It is supported on insulators about 12 inches above the metal framework and is so low that it does not interfere with taking on water and coal. It was found advisable to mount it on the tender instead of the locomotive boiler. On the caboose a simple wire antenna is provided.

Rear of Tender Showing Radio Equipment and Antenna

Before leaving the Selkirk Yards the observers inspected a similar type of radio telephone transmission in use there on a switch engine serving the hump over which freight cars run in the classification process. In this case the hump locomotive is equipped with a radio receiver and loud speaker, and the engineer is directed by voice instructions from the yard master direct. This apparatus has been in service for several months and is giving very satisfactory results, particularly in stormy or foggy weather, when the older signal methods were difficult to carry out.

Prevention of Excessive Smoke From Locomotives*

By J. F. BJORKHOLM, Asst. Supt. of Motive Power, Chicago, Milwaukee, St. Paul & Pacific Railway

A serious problem confronting bituminous coal burning industries is smoke abatement. The question is an economic issue of major importance because it does not only embrace the particular industry or community directly affected, but the coal producing regions serving the territory involved and may spell industrial progress or retardation. We all admit that dense black smoke is a nuisance and toward the elimination of which we must all lend our aid.

One of the serious questions confronting any one burning bituminous coal, as well as the producers of this product, is that frequently legislation is passed prescribing a certain kind of fuel for the purpose of eliminating smoke without any thought of the economic issue involved.

In order that the desired result may be accomplished in the matter of smoke abatement, education on the subject is a very vital factor. While at first it may appear to a simple matter to avoid offensive smoke from a locomotive or a power house boiler, we find that the problem is sufficiently complicated to cause many to proceed on entirely wrong theories. The reason for this, as I see it, however, is frequently because thorough consideration has not been given to the principles of combustion before some action has been taken towards smoke elimination. Please bear in mind that "smoke painting" or the "white-washing" of smoke, and the actual prevention of smoke are two different things,—one entirely wrong, the other a procedure along proper scientific lines—and still it is surprising to find how many neglect the problem of preventing the formation of smoke as far as it can be prevented and are entirely contented with "smoke painting." The latter is merely camouflage as, while the smoke may not appear black when leaving the stack, or chimney, the fact remains that the offensive smoke has merely been discolored by wet steam, or vapor, while with proper methods, the actual formation of smoke has been prevented by improved combustion and a fairly clear stack is the result. In this connection I might mention that the terms "smoke burning" or "smoke consumption" are misnomers, because smoke already formed ordinarily cannot be burned or consumed. In order to get the desired result, the smoke must be prevented from forming.

We must recognize that many an ordinance regulating this or that practice has come into existence on account of certain abuses, whatever their nature may be, abuses that could just as well have been corrected prior to such legislation as subsequent to it. In the matter of smoke from locomotives, it is not uncommon to find cases, particularly at small country towns and occasionally in our large terminals, where a fireman thoughtlessly will permit clouds of the densest kind of smoke to be emitted, polluting the atmosphere and blackening buildings in a manner that causes one to wonder why every town and village has not placed some kind of an ordinance on its statute books with a view of combating the smoke nuisance.

When we think of smoke abatement, we usually think of the fireman on the locomotive because, particularly after he has been in service a sufficient period to be classed as an experienced fireman, we look to him to fire the locomotive in a manner that no reasonable causes for complaints be forthcoming. The engineer, while he must be relied upon to educate the new fireman with the assistance rendered by traveling engineers, traveling firemen, fuel supervisors and smoke inspectors and, of course, must assume his share of the responsibility, is usually occupied with many other duties and cannot always be expected to watch the stack. The fireman, on the other hand, should experience no difficulty in maintaining the fire in such a condition that no objectionable smoke be emitted. Given the proper equipment with which to do the work, he should be called upon to do his work properly. It is true, that there are cases when the combination of maintaining maximum steam pressure and also guarding against smoke violation is somewhat difficult, particularly when an engine is called on to deliver suddenly its maximum effort without first giving the fireman an opportunity to get the fire well started. Such cases are in the minority, and even in such cases a careful fireman can do wonders in guarding against black smoke.

Perfect combustion is difficult to attain in a locomotive firebox, but through careful studies of the various elements entering into the matter of combustion when building the locomotive, coupled with skillful firing, fairly good results are attained. Locomotive builders in recent years have given more thought to economy in fuel in designing new engines and converting old ones than to any other feature, and we must admit that they have accomplished considerable in that respect. Economy in fuel consumption means a slower rate of combustion which in itself is an aid in the reduction of black smoke.

Without going into any technical terms in the matter related to combustion, we all know that in order to burn coal properly, a sufficient amount of air must be admitted into the firebox, or furnace, as the case may be, some of which should be admitted to the top of the fuel bed.

The greatest difficulty in avoiding offensive smoke is usually on switch and transfer engines, owing to the very nature of their work, and on road engines starting out of the initial terminal, particularly if a hard pull has to be contended with before the fireman has had an opportunity to get the fire well started. Under such circumstances it is usually necessary to depend on the blower and the so-called "smoke burners" which are not smoke burners but smoke preventors by which additional air is admitted into the firebox, causing the combustible matter escaping from the coal to ignite and burn instead of escaping through the smoke stack in the nature of black smoke, which is fuel only partly burned.

The method employed is usually a number of so-called combustion tubes located in the side sheets of the firebox and through which a steam jet causes a flow of air to enter the firebox above the burning coals. While in most instances the arrangement is rather crude and too much steam is used, the principle is right and no doubt can be considerably improved on without much expense. In this connection it should be borne in mind that there are no properties in the steam which aid combustion; the steam jet is merely the mechanical means of causing the air to be drawn into the firebox. It is true, of course, that inasmuch as steam is nothing but water, and water contains a certain amount of oxygen, there is a small amount of oxygen present in the steam, but not of sufficient quantity to be considered of any value as an agent aiding combustion. When steam is admitted into the firebox, it is decomposed by the heat into its constituents, hydrogen and oxygen. This process, however, absorbs

*From a paper read before the Kansas City, Mo., Smoke Abatement Committee.

as much heat as possibly can be developed by the combustion of the hydrogen formed and thus it follows that very little gain in this respect can be accomplished by the mere introduction of steam. On the other hand, there is always the possibility that the introduction of steam through its decomposition causes a reduction in temperature to the detriment of proper combustion. The practice of inserting several steam jets into a firebox unless the jets induce an air current to flow, is merely "smoke painting" and an expensive practice. In this connection it would perhaps be well to mention that it requires approximately 320 lb. of coal per hour to furnish steam for a ⅜-in. pipe with the steam constantly flowing at 190 lb. pressure. This is a very important item to keep in mind when blowers usually have a greater steam supply than that flowing through a ⅜-in. pipe; in fact either a ¾-in. or 1-in. pipe is usually employed.

A sufficiently high firebox temperature is also a necessary factor in aiding combustion and thus reasonably guarding against objectionable smoke. The air entering the firebox above the fuel bed should enter in several small jets instead of one or two large jets. The firebox door, if open, will usually serve the purpose, but is an expensive and unsatisfactory practice as through this method the air is admitted in too large a quantity in one place which absorbs too much of the firebox temperature and thus causes an excessive fuel consumption, as well as being detrimental to the firebox and flues.

Two of the most essential, but at the same time very simple rules to remember are: First, that gases that have been cooled below the temperature of ignition, cannot be burned merely by furnishing a supply of air. Second, that when the gases are supplied with air, they can be burned if their temperature is raised to the ignition point. A temperature of at least 1,800 deg. F. is essential to insure fairly satisfactory results. This temperature can be judged by the bright red color of the fire. Bright orange or white heat with a temperature of 2,100 deg. and 2,350 deg. F., respectively, are of course, to be preferred, while a dull red color with a temperature of approximately 1,500 deg. F. is too low to prevent a lot of unburned gases from escaping through the smoke stack.

The boilers usually employed on locomotive cranes of various kinds that are to be found in a railroad terminal. On account of the very short flame-way possible with this type of bolier, the gases escape before given sufficient time to burn thoroughly. The best method of guarding against objectionable smoke from this type of boiler is the method of injecting several small air jets towards the center of the firebox, thus insuring abundant oxygen, as a rule not otherwise available in the fireboxes of this type of boilers.

In the matter of stationary power plants, the question of smoke elimination can more readily be regulated than is possible on locomotives or cranes, as with the former the question of limitations is not as pronounced as with the latter. As with the locomotives, the load, of course, largely enters into the problem, but with the proper stack capacity and the proper brick work with baffles properly placed, ordinary care on the part of the fireman should cause a fairly clean stack. As in the case of locomotives, carelessness too often is the direct cause of the trouble.

In order to accomplish good results, however, good tools must be furnished the man who makes or prevents the smoke—the fireman. We must always bear in mind, however, that the solution of the problem depends more on intelligent work on the part of the fireman, than any device that can be put at his disposal. It is necessary that the grates be thoroughly clean so as to permit, as far as possible, an unrestricted flow of air to enter the firebed and without which the fireman is placed at a decided disadvantage. In addition, the ashpan should be so constructed that sufficient air is always available. The grate shaker rigging should be so maintained that the grates may be shaken whenever necessary so as to cause the dead ash, blocking the entrance of the air into the firebox, to be removed. The brick arch should be properly maintained and cleaned at regular intervals, the latter also being true with the flues. In addition, the front end appliances should be properly dusted so as to insure a good steaming engine and with a good steaming engine at his disposal, the fireman should experience very little difficulty in so firing the locomotive that complaints should be the exception instead of the rule.

The proper method of firing at all times is, of course, to put into the firebox at each firing only a sufficient amount of coal that will insure proper combustion. By following such a practice, a clean fire can be maintained without any difficulty and in addition, an economical use of the fuel is the result. The most wasteful method of firing is, of course, to throw into the firebox large quantities of fuel at one time. This is usually accompanied by the safety valves opening and too much water being put into the boiler. This, in turn, causes too much time to elapse before the next fire is needed, with the result that the firebox temperature has been lowered considerably and as a result, black smoke will follow. If, when within the terminal limits where smoke ordinances usually govern, the fireman will fire carefully and the engineer cooperate in operating the engine in a manner consistent with conditions, with a conservative use of the blower, ordinarily there ought not to be much trouble from smoke. Occasion may at times demand the use of the so-called "smoker burners" for a short time.

Motor Transport Division Organized

The newly authorized Motor Transport Division of the American Railway Association perfected its organization at its first meeting held recently in Chicago, with the election of officers and a general committee to serve until October, 1929. The meeting was attended by about ninety delegates, representing more than seventy of the principal railroads in the United States and Canada.

The object of the division is to establish a clearing house for transportation thought and development of motor transportation by railroads, and for studying the problem raised by highway competition in order to determine the facts and fundamental principles involved. Studies and reports of the division will be made on each territory, with its specific problems and its methods for meeting them, as the needs or desires of the member roads indicate.

The division is organized in three sections dealing, respectively, with the study of the application of the motor coach, the motor truck, and the rail motor car to the use of steam railroads. The importance of the general field and its international interest is evidenced, according to a statement made at the meeting, by the fact that delegations from England, Japan, Australia, and Germany have already visited this country to investigate American railroad activity in the field of motor transportation.

Inquiries have also been received from railways in Chile, Switzerland, Sweden, Japan, Cuba, Australia, and England regarding the motor transport problems confronting the American lines and the methods by which they are being met.

The following officers were elected:

Chairman, A. P. Russell, vice-president, New York, New Haven & Hartford. Vice-chairman, motor coach section, T. B. Wilson, vice-president and manager, Southern Pacific Motor Transport Company. Vice-chairman, motor truck section, G. C. Woodruff, assistant freight traffic manager, New York Central. Secretary, G. M. Campbell, assistant to secretary, American Railway Association. R. L. Fairbairn, passenger service manager, Canadian National, was elected vice-chairman in charge of the rail motor car section.

In addition to the foregoing officers, the organization includes a general committee, which will exercise supervision over the interests and affairs of the division. The chairman and vice-chairman are ex-officio members of the general committee. The following other members were elected:

J. G. Drew, vice-president, Missouri Pacific; H. F. Fritch, passenger traffic manager, Boston & Maine; A. Hatton, general superintendent of transportation, Canadian Pacific; C. S. Lake, special assistant to president, Chesapeake & Ohio; G. W. Lupton, assistant to vice-president, Atchison, Topeka & Sante Fe; R. K. Stackhouse, general superintendent stations, transfers and motor service, Pennsylvania; R. N. VanDoren, vice-president and general counsel, Chicago & North Western.

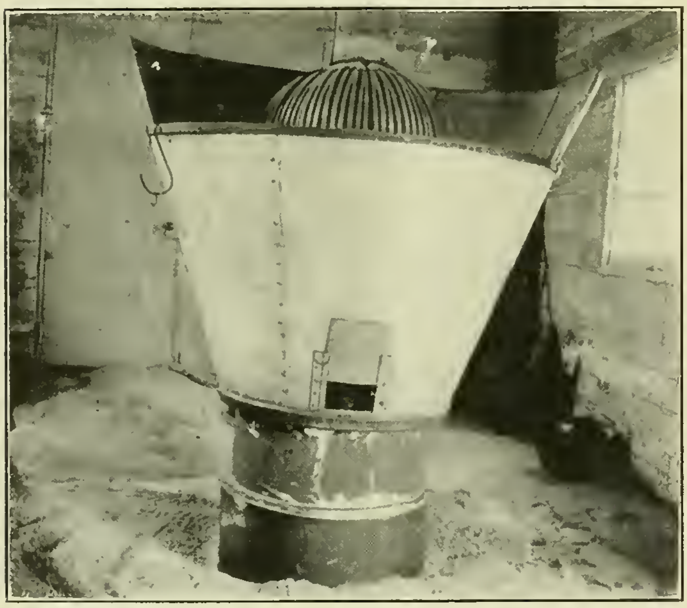
The next meeting will be held at Atlantic City, June 21 and 22.

Drying and Supplying Sand to Locomotives

By Charles W. Geiger

The accompanying illustrations show a novel sand dryer and the rather efficient method employed in supplying sand to the locomotives of the California State Harbor Board which are operated along the water front of San Francisco, Cal.

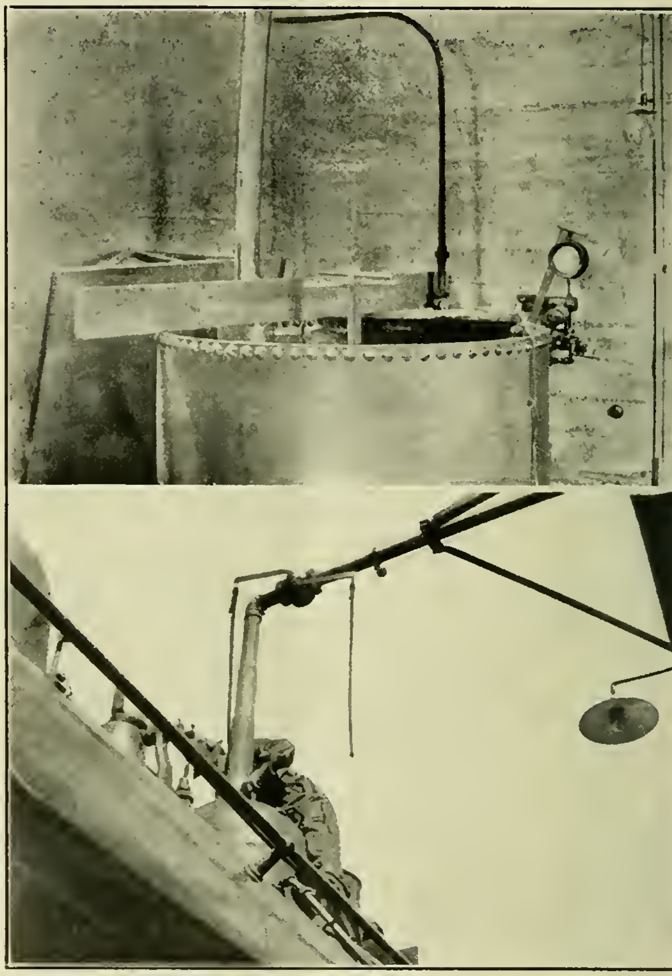
The dryer is built in three sections, the base being a cast iron drum. A cone shaped funnel is built which



A Novel Dryer for Locomotive Sand

provides considerable space between the cast iron drum and the sheet iron drum for the wet sand. The wet sand is shoveled into the top and as it becomes dry runs out through perforations in the bottom of the sheet iron drum, collecting around the base of the heater on the floor. When a pile of dry sand reaches such a height that it would stop the drying sand from running down through the perforations it is shoveled into the storage bin.

In the sand drying plant there is a steel drum with a conical shaped top into which the dry sand is shoveled. In the lower part of the conical shaped top there is a hole through which the sand runs into the drum. When the drum has been filled with sand to the proper height, a cap is screwed over the hole and compressed air turned into the top of the drum. A large pipe extending from



Locomotive Sanding Devices Used by the California State Harbor Board

the bottom of the drum makes a big bend and ends on the outside of the sand drying plant at a point directly over the rails, where there is a quick opening valve and a telescopic sand delivery pipe which is adapted to extend down into the sand drum on the locomotive. When the valve is opened the air pressure forces the sand into the drum quickly and without spilling.

Transportation Fifty Years from Now

Fifty years from now the railroads will still be performing the bulk of our transportation service, particularly in freight, is the opinion of Samuel Rea, Retired President, Pennsylvania Railroad. Mr. Rea's analysis of this question was contained in a recent address before the Engineers Club of Philadelphia, upon the occasion of its fiftieth anniversary. He said in part:

"The movement of all commodities will increase tremendously in fifty years, due to the decentralization of industry and population as well as the enormous increase in the buying power of the nation. Just how great an increase of freight movement is likely, in mathematical terms, it would be foolish for anyone to attempt even to guess; but it will be very large.

Water Transport

"Besides railroads, we will have water transport, highway transport and transport in the air, as at present. With reference to water transport, I can frankly say that I see no future worth speaking of for inland canals or the canalization of rivers not naturally navigable, at least in a country such as ours, and with such waterways open only a part of each year. The expenditure of further money for projects of this character is, to my mind, in the great majority of cases, nearly a one hundred per cent waste, and I do not think the situation in 1978 will be any different from the present. As a matter of fact, the inland canal era in this country ended at least fifty years ago.

"In their relations to railroads, the most important function of motor vehicles will doubtless be to act as collectors and distributors at terminals, inter-terminal hauls being more efficiently performed by rail. Motors will doubtless absorb in the future a greater proportion of the shorter distance passenger traffic than at the present time. In the freight field their economic utility will always be more circumscribed except for collecting and distributing purposes in terminal zones and for reasonable distances around towns and cities. In the great majority of cases, comparatively long hauls of freight, in any considerable quantity must in the nature of things be better and more economically performed by rail.

Air Transport

"My expectation is that air transport will evolve a de luxe high-speed passenger service with genuine, but distinctly limited, utility for long distance travel and special requirements, and at necessarily high rates. I do not think it can possibly be a factor of any moment in freight service, though it doubtless will develop a field in express service for light articles, at high charges. In fact a beginning is already being made in this respect.

"In so far as the railroads themselves are concerned the progress of the next fifty years seems likely to be more a matter of orderly development than of radical change. This is not surprising in view of the fact that the railroads today represent the evolution of a full century of cumulative knowledge and experience. In the way of further improvements and betterments along lines already understood, however, there are almost unlimited possibilities, and the question how far we will be able to go in giving the country better railroads in the next half century is chiefly a question of what the railroads will be allowed to earn."

The Sulzer Diesel Locomotive

A locomotive was recently supplied to the Tunisian Railroad Co. in which the normal output of the Diesel engine was rated at 250 b. h.p. The Diesel engine is direct coupled to a dynamo supplying current to the four motors driving the four axles of the locomotive which shall be able when drawing a load of 80 tons to develop a speed of 37½ m.p.h. on the level, 23 m.p.h. when ascending a gradient of 1 in 100, and 12 m.p.h. up a gradient 1 in 70.

In trails the locomotive drawing a full load of 80 tons on the level showed an average fuel consumption of 9.928 lb. per ton-mile. The locomotive is equipped with a Sulzer airless-injection four-cycle Diesel engine with the eight cylinders arranged obliquely. Running at 550 r.p.m. the engine develops 250 b. h.p., but the output may be raised temporarily to 300. The engine is started by the generator as a motor with current from storage battery. When the engine has reached normal speed the generator is automatically switched over to act again as a generator. The storage battery is then again automatically charged up from the charging generator.

All working parts are provided with forced lubrications. The cylinders are water cooled, the cooling water flowing in a closed circuit and being circulated by means of two centrifugal pumps driven by the engine itself. The warm water from the cooling jackets is led to a cooler set on the roof of the locomotive and provided with a powerful fan. Because of the hot weather usually prevailing in Tunis, the temperature of the cooling water can be observed in the driver's cab by means of an electric thermometer. The electric part of the locomotive includes a special generator for charging the storage battery. It is designed for an output of 25 kw. and also supplies current for the fan motor.

An Automatic Underground Railway

After many years the undertaking which bears the official name of the Post Office (London) Railway is at work. It is a deep-tunnel line west and east through the heart of London. It is probably unique. No passengers, nor freight apart from the mails, are carried, and no operator nor any other person travels on the trains; these are operated from the stations. The whole undertaking is a most interesting application of electric traction.

It is a long time since the British Post Office authorities came to the conclusion that it would be desirable to replace the road truck service they were using by a better method of transporting the letter and parcel mails between the principal post offices and railway stations in London, with a view both to accelerating the service and contribution to the reduction of the street congestion. It was decided that the best results would be obtained by employing an automatic railway system which electrically operated trains without operators, control being effected from special cabins at the various stations along the line. The first contracts were let, and the tunnelling work was started just after the war broke out. This world catastrophe naturally necessitated a change of policy. It was decided, however, to complete the tunnelling. No further progress was, however, made until after the Armistice, the tunnels being meanwhile employed for storing works of art.

The railway runs from Paddington railway station and district post office in the east, connecting on the way with the other post offices and railway station at Liverpool Street. The undertaken, will provide direct underground connection between the principal railway stations and post offices in London. The total length of the railway, as at present constructed is 6½ miles.

The gauge is 2 ft., which is the first permanent 2-ft. gauge railway in Britain. In order to economize expenditure it was decided to run both tracks in one tunnel. The minimum size tunnel requisite was one of 9 ft. internal diameter, and this was therefore chosen.

Supplies of electricity for operating the traction and other equipment on the railway are drawn from the mains of the City of London Electric lighting and the Charing Cross and City Electric Companies.

Train Operation

The rolling-stock consists of steel motor cars, which are made up into trains of two or three vehicles. Each car is capable of carrying a load of 1,120 lb. The electrical equipment of the cars is simple, consisting principally of two 22 hp. 440-volt direct-current series motors, which are connected permanently in parallel. It also includes a resistance in series with each motor, which again is permanently in circuit, and a set of electrically-operated braking equipment and reverser. The whole of the operation of the trains is automatic, control of the starting and stopping being effected from switch-cabins at each station. No drivers are required.

The car motors are energized in the ordinary way from the conductor-rail, which is divided into sections, each section being controlled either by automatic track circuits on the sections between the stations or by levers working under track circuit control in the station areas. These levers are concentrated in the various switch-cabins. To start the train, its proper route is set up and the conductor-rail is energized at 440 volts, so that it runs off down a falling gradient. The maximum speed reached is about 35 m.p.h. When a station is approached, the train enters a section on a rising gradient in which the conductor-rail is dead, and is brought to rest by the automatic operation of the brakes. After a short interval the conductor-rail in this section is energized at 440 volts and remains energized at that voltage for a predetermined time, which is sufficiently long to give the train a good start. At the end of this period the voltage is reduced to 150 volts, and the train runs into the station under this pressure. Battery locomotives are provided for maintenance purposes and the haulage of broken-down trains. A train passing through a station, at which it is not scheduled to stop, does not require the continuous attention of the switchman, but its position in the tunnels and its destination are notified to that official by illuminated diagrams in the control-cabin at the station. He is thus able to receive the train by pulling a lever, which sets the points for the appropriate route, and energizes the various controlled sections of the conductor-rail. Generally, it may be stated that the method of controlling the station sections is based on the well-known "one-lever" railway signalling system of the Siemens and General Electric Signalling Company, Ltd., who acted as sub-contractors to the English Electric Company, while the conductor-rails in the tunnel sections are energized through contactors, which are operated by relays working on railway signalling principles.

Moffatt Tunnel Completed

With the opening of regular train service through the Moffatt tunnel east of Denver, a shorter transcontinental railway route was a step nearer completion. Regular train service will be inaugurated through the tunnel in March.

The tunnel is 6.2 miles long and pierces the continental divide at an elevation of about 9,200 feet. It is 60 miles west of Denver, Colo., on the line of the Denver & Salt Lake Railroad. It was started in 1923 in conformity with the plans of the late David H. Moffatt, pioneer western railroad builder and cost approximately $18,000,000.

While the tunnel was built to cut upwards of 180 miles from transcontinental routes, this plan cannot become effective until connections with lines west of the continental divide are completed. The original proposal was to link Craig, Colorado, western terminus of the Denver & Salt Lake Railroad, with Salt Lake City by building about 250 miles of track. Other routes have been proposed, but road officials have declined to comment on them.

The tunnel has been leased for 50 years by the Denver & Salt Lake Railroad, the only line which now has access to it. Construction of the tunnel has always been considered as an essential element for the more successful operation of the road because of the difficulties attending the movement of its trains over the so-called temporary line which crosses Rollins Pass at an elevation of 11,660 ft. above sea level, involving grades of four per cent for a total distance of 27 miles, and imposing the severest of winter conditions for nine months of the year.

With the completion of the tunnel these difficulties have been largely eliminated. However, the advantage is offset in part by the fact that the railroad must pay rent and other expenses incident to its use of the tunnel which range from $329,660 to $536,740 annually for the first 36 years.

The Moffatt tunnel is the longest completed bore on the North American continent. The Great Northern Railway is building a tunnel through the Cascade mountains in Washington which will be nearly eighty miles in length.

Railways Urge Control of Buses

Immediate enactment of a law by which the Interstate Commerce Commission can exercise at once a measure of control over motor bus routes and their location is urged in a petition sent to the commission on behalf of seven railroads operating in New York, New Jersey and Pennsylvania.

Particular complaint was directed at the competition offered by motor buses and trucks crossing the Delaware River at Philadelphia, and various Hudson River points between New York City and New Jersey. The roads taking part in the appeal were the Pennsylvania Railroad Company, West Jersey & Seashore Railroad Company, the New York & Long Branch Railroad Company, the Delaware, Lackawanna & Western Railroad Company, the Central Railroad Company of New Jersey, the Atlantic City Railroad Company and the Reading Company.

The commission has before it a tentative report from Examiner Flynn suggesting measures for general supervision of motor bus traffic and legislation to carry this into effect is contemplated by certain Congressional leaders. There are prospects that a long drawn-out fight will attend any effort to enact a law. The memorandum of the seven railroads points out that the problem presents many complexities, with wide differences of opinion.

"There is one point, however," it was declared, "on which there is general accord, that is the urgent need for the prompt regulation of Interstate motor buses."

Their operation between Philadelphia and New Jersey points across the new Camden bridge and between Northern New Jersey points and New York City via ferries and the Holland Tunnel was described as such that heavy inroads into the income of the railroads is resulting.

"Confronted with heavy and increasing losses of revenue from the operation of Interstate motor buses," said the statement for the roads, "the carriers on whose behalf this memorandum is filed urgently need relief through the prompt enactment of a Federal law providing for the regulation of Interstate motor buses.

"Such a law must be the first step in dealing with the problem of co-ordinating rail and motor transportation. The above named railroad companies believe that a law constituting an authority to determine the primary question whether public convenience and necessity require the operation of interstate motor buses on particular routes should be passed with the least possible delay.

The commission was urged to report the situation to Congress accordingly with recommendations that it be given authority to pass upon the point raised as promptly as possible.

The appeal for the roads was signed by H. Z. Maxwell, Douglas Swift, A. H. Elder and W. L. Kinter.

Locomotive and Car Conditions

Locomotives in need of repair on the Class I railroads of this country on January 1, totaled 8,257 or 13.6 per cent of the number on line, according to reports just filed by the carriers with the Car Service Division of the American Railway Association.

This was a decrease of 891 locomotives compared with the number in need of such repairs on December 15, at which time there were 9,148 or 15.1 per cent.

Locomotives in need of classified repairs on January 1 amounted to 4,406 or 7.3 per cent, a decrease of 440 compared with December 15, while 3,851 or 6.3 per cent were in need of running repairs, a decrease of 451 compared with the number in need of such repairs on December 15.

Class I railroads on January 1 had 7,490 serviceable locomotives in storage compared with 6,754 on December 15.

Class I railroads on January 7 had 461,669 surplus freight cars in good repair and immediately available for service, the Car Service Division of the American Railway Association reports.

This was a decrease of 2,336 cars compared with December 31, at which time there were 464,005 cars.

Surplus coal cars on January 1 totaled 177,166, a decrease of 6,472 cars within approximately a week, while surplus box cars totaled 229,362, an increase of 5,115 for the same period.

Reports also showed 24,534 surplus stock cars, a decrease of 1,354 under the number reported on December 31, while surplus refrigerator cars totaled 14,261, an increase of 332 for the same period.

Thirty Locomotives for Russia

The Geo. D. Whitcomb Company of Rochelle, Illinois, have announced the securing of a foreign order for locomotives that is probably one of the largest orders placed for industrial locomotives since wartime buying ceased.

The order covers thirty locomotives for the Russian Imperial Railways Commission.

The Russian authorities were represented by the Amtorg Trading Corporation of New York City, who have been placing heavy orders lately for construction machinery and materials for use in Russia. During 1927, the Amtorg firm placed orders on behalf of Russia totalling $27,000,000, and the construction program that is to be carried out in 1928 calls for a greatly increased expenditure.

The locomotives purchased from the Whitcomb Company are to be used in building 1,000 miles of new railway from a junction with the present trans-Siberian railway, south through Turkestan to a point near Afghanistan. This district has immerse stores of natural resources that have never been exploited for lack of transportation facilities, and the new line will open up this rich territory.

The region to be traversed is primitive and wild, inhabited only by nomadic tribes. In carrying out the work, the construction forces will be compelled to transport much of their material by trucks and mule trains. The equipment and supplies for the entire job are being carefully selected, in view of the fact that the work is to be carried out several thousand miles from the source of supplies.

The locomotives are all of the internal combustion type, powered with heavy duty Climax engines. They will be fitted to burn kerosene and will develop 122 horsepower at a speed of 1000 revolutions per minute. The order includes twenty twelve-ton and ten eighteen-ton engines.

Notes on Domestic Railroads

Locomotives

The American Rolling Mill Company has placed an order for 1 one hundred-ton oil electric locomotive to be built by the Ingersoll Rand, General Electric, and American Locomotive Companies.

The New York, Ontario Railway will buy six 4-8-4 type locomotives.

Government of Siam has ordered 8 locomotives from Baldwin Locomotive Works.

The Donner Steel Company, Buffalo, N. Y., has placed an order for 1 sixty-ton oil electric locomotive to be built by the Ingersoll Rand, General Electric, and American Locomotive Companies.

The Mobile & Ohio Railroad has ordered 5 Mikado type locomotives from the American Locomotive Co.

The Quarahuy Eitaquy Estrado de Ferro, Brazil, has ordered one Pacific type locomotive from Baldwin Locomotive Works.

The Toronto, Hamilton & Buffalo Railway has ordered two 2-8-4 type locomotives from the American Locomotive Co., Montreal Works.

The Mud Valley Logging Company, Olympia, Wash., has ordered one 2-6-6-2 type Mallet locomotive from the Baldwin Locomotive Works.

The Texas & Pacific Railway has ordered 15 Texas type locomotives from the Lima Locomotive Works, Inc.

The Mexican Railway has ordered 2 three-cylinder Pacific type locomotives from the American Locomotive Company. These locomotives will have 20 in. by 28 in. cylinders and a total weight in working order of 252,000 lb.

The Western Lumber Co. has ordered a Prairie type locomotive from the Baldwin Locomotive Works.

The Union Pacific System has ordered 23 three cylinder 4-12-2 type locomotives and 15 additional 12 wheel tenders of 18,000 gal. capacity from the American Locomotive Company. The locomotives will have 27 by 31 in. cylinder inside and 27 by 32 in. outside, and a total weight in working of 495,000 lb.

The New York Central Lines is inquiring for five 4-6-4 type locomotives and five 4-6-6 type locomotives, for the Boston & Albany.

The Sinclair Refining Company has ordered a six-wheel switching locomotive from the Baldwin Locomotive Works.

The Alabama State Docks Commission has ordered a six-wheel switching locomotive from the American Locomotive Company. This locomotive will have 21 by 28 in. cylinders and a total weight in working order of 164,000 lb.

The Tennessee Copper Company has ordered 1 six-wheel switching locomotive from the American Locomotive Company.

The Northern Pacific Railway has ordered one 2-8-8-4 articulated type locomotive from the American Locomotive Company. The total weight in working order of this engine will be 710,000 lb. and, including tender loaded, 1,802,500 lb.

Passenger Cars

The Chicago, Burlington & Quincy Railroad will purchase 6 baggage, and three combination passenger-baggage cars.

The Long Island Railroad has ordered 10 coaches from the American Car & Foundry Company.

The Great Northern Railway has ordered 5 combination baggage and mail 73 ft. gas electric rail motor cars from the J. G. Brill Co.

The Nashville, Chattanooga & St. Louis Railway has ordered 2 steel combination passenger and baggage cars and 2 steel baggage cars, all to be 70 ft. long, from the American Car & Foundry Company.

The Mobile & Ohio Railroad has ordered 3 steel passenger coaches and 3 steel passenger coaches with partitions from the Bethlehem Steel Co. They have also ordered 3 72 ft. mail and baggage gas-electric rail and motor cars from the St. Louis Car Co.

The St. Louis-San Francisco Railway has ordered 15 combination steel baggage and mail cars and 5 steel baggage cars, all 70 ft. in length, from the American Car & Foundry Co.

The New York, Westchester & Boston Railway has ordered 25 electric passenger cars, 10 from the Westinghouse Electric & Mfg. Co., and 15 from the Osgood Bradley Car Co.

The Chicago, Rock Island & Pacific Railway is inquiring for 11 gas electric rail motor cars.

The Pennsylvania Railroad has placed orders for 300 standard all-steel 70 ft. passenger coaches, 210 standard all-steel 60-ft. baggage cars and 29 standard all-steel 70 ft. combined passenger-baggage cars, for delivery during the current year. Besides these new coaches and baggage cars, the Altoona works will construct 45 all-steel 70 ft. scenery cars and 25 all-steel 74 ft. horse express cars.

Pittsburgh Railways have ordered 15 interburban passenger coaches from the St. Louis Car Co.

The Union Pacific System has authorized the purchase of six 275 h.p. gas-electric passenger rail motor coaches and eight 70-ft. mail and baggage trailers. They will also purchase 10 dining cars.

The Southern Railway has ordered 1 baggage and mail car from the Bethlehem Steel Co.

The Central Railway of Brazil, has ordered 12 passenger train cars from the American Car & Foundry Company.

The Reading Co. is in the market for 2 gas electric cars.

The St. Louis-San Francisco Railway is inquiring for 5 rail motor gas-electric cars.

The Delaware & Hudson Company has ordered 3 all steel combination mail and baggage cars from the American Car & Foundry Company.

The Texas & Pacific Railway has ordered 2 business cars from the American Car & Foundry Company.

The Minneapolis, St. Paul & Sault Ste. Marie Railway has ordered eighty combination baggage and smoking cars from the Pullman Car & Manufacturing Corporation.

The Chicago, Indianapolis & Louisville Railway is inquiring for one gas-electric rail motor coach.

The Long Island Railroad has ordered two combination baggage and mail cars from the American Car & Foundry Company.

The Manitoba Power Company, Winnipeg, Man., has ordered one 52-ft. single-unit gas-electric rail motor car from the Mack Trucks, Inc.

The State Railways of Uruguay are inquiring for bids for the construction of the following equipment: 3 first class passenger coaches, 1 first class Pullman coach, 2 dining cars, first class, 2 baggage cars, 10 box cars, 32 stock cars and 1 auxiliary crane.

Bids should be received not later than May 1, 1928, and inquiries should be addressed to José Figueira, secretary, Directorio de Ferrocarriles y Tranvias del Estado, Montevideo, Uruguay.

The Paulista Railway of Brazil is inquiring through the car builders for 7 sleeping cars.

The Chicago, Rock Island & Pacific Railway is inquiring for 10 baggage cars, 6 baggage and mail cars, 10 suburban cars and 10 coaches.

The Reading Company has ordered one double power plant combination passenger, baggage and mail gas-electric rail motor car, from the J. G. Brill Company.

The New York, Chicago & St. Louis Railroad has ordered one private car from the Pullman Car & Manufacturing Corporation.

The Chicago & Alton Railroad has ordered 7 baggage and mail cars and 2 postal cars from the Pullman Car & Manufacturing Corporation.

The Union Pacific System has ordered 15 coaches and 10 dining cars from the Pullman Car & Manufacturing Corporation.

Freight Cars

The Norfolk & Western Railway has given an order to the Ralston Steel Car Company for rebuilding 1,000 hopper coal cars of 57½ tons capacity.

The Minneapolis, St. Paul & Sault Ste. Marie Railway is inquiring for 200 box cars.

The Nashville, Chattanooga & St. Louis Railway has ordered 500 center constructions of cars, from the Tennessee Coal, Iron & Railroad Company.

The Central of Georgia Railway is inquiring for 500 flat cars.

The Mobile & Ohio Railroad has ordered 3 72 ft. mail and baggage gas-electric rail motor cars from the St. Louis Car Company.

The Chesapeake and Ohio Ry. has given awards for new equipment totaling $775,000, the equipment consisting of 500 70-ton steel hopper bottom gondola car bodies, removing and dismantling car bodies from trucks, cutting and loading the scrap and making the necessary repairs to the trucks. The award for 300 of these cars went to the Richmond Car Works, and for 200 cars to the American Car & Foundry Co.

The Pacific Fruit Express is now inquiring for 2,000 refrigerator cars.

The South African Railways are inquiring for 100 40-ton gondola cars.

Butler Brothers, Ironton, Minn., has ordered 8 twenty-cu. yd. air dump lift door type cars, from the Koppel Industrial Car & Equipment Company.

The Southern Railway System has ordered 500 automobile cars from the American Car & Foundry Co.

The Sharples Solvent Corp., Charleston, W. Va., has ordered 4 tank cars of 6,000 gal. capacity, from the General American Tank Car Corp.

The Sinclair Refining Company is inquiring for 5 coke cars.

The Chicago, Great Western Railroad has ordered 50 stock car underframes from the Bradford Corporation.

Wilson & Co. are inquiring for 300 refrigerator cars of 40 tons capacity.

The Texas Co. has ordered 200 insulated 10,000 gal. tank cars from the American Car & Foundry Co.

The American Smelting & Refining Company is inquiring for 60 gondola cars.

The Woodward Iron Company has ordered 50 mine cars from the American Car & Foundry Company.

The Carnegie Steel Company has ordered 15 tank cars from the Petroleum Iron Works and 35 from the Standard Tank Car Company.

The Chesapeake & Ohio Railway has ordered 300 seventy-ton hopper car bodies from the Richmond Car Works and 200 from the American Car & Foundry Company.

The Central Georgia Railway has ordered 500 gondola cars from the Tennessee Coal, Iron & Railroad Company.

The Bangor & Aroostook Railroad will build 100 single sheathed box cars in its shops at Derby, Me.

The H. C. Frick Coke Company has placed orders for the repair of 274 freight cars with the Greenville Steel Car Company, and 93 with its own shops.

The St. Louis-San Francisco Railway has ordered 100 steel frame single sheathed 50 ton box cars and 500 steel 55 ton hopper cars from the American Car & Foundry Company; 500 hopper cars and 500 automobile cars from the Pullman Car & Manufacturing Corporation; 500 hopper cars, 500 flat cars and 500 box cars from the General American Car Company.

The Chicago, Milwaukee, St. Paul & Pacific Railroad is inquiring for 4,650 freight cars as follows: 1,000 hoppers of 70 tons capacity; 2,500 box cars of 50 tons' capacity; 650 stock cars of 40 tons' capacity; 300 automobile cars of 50 tons' capacity and 200 75-ton ore cars.

The Fruit Growers' Express has ordered 152 refrigerator car underframes from the Pressed Steel Car Company.

The Wheeling Steel Company has ordered four 20-cu. yd. and 12 20-cu. yd. lift door type, air dump cars from the Koppel Industrial Car & Equipment Company.

The South Manchurian Railway is inquiring through the car builders for about 20 air dump cars of 45 cu. yd. capacity.

The Swift Company has ordered 300 steel underframes for refrigerator cars from the Bettendorf Company.

The St. Louis-Southwestern Railway has ordered six caboose car underframes from the Virginia Bridge & Iron Company.

The Union Pacific System has ordered 500 flat cars of 50 tons' capacity from the Bettendorf Company.

The Conley Tank Car Company has ordered 50 tank cars of 40 tons capacity from the American Car & Foundry Company.

Supply Trade Notes

A. E. Ostrander, who has had a wide range of experience in the railway engineering and equipment fields, has been appointed foreign sales manager of the **American Car and Foundry Export Company.** Mr. Ostrander has been for the past 25 years with the concern of whose foreign business he now takes charge. During his earlier career he was associated with General Cornelius Vanderbilt, the New York, New Haven & Hartford Railroad and the Standard Steel Car Company.

T. M. Girdler has been chosen president of the **Jones & Laughlin Steel Corp.**, Pittsburgh; **W. J. Creighton** becomes vice president; **R. J. Wysor** is made works manager.

George A. Nichol, Jr., general manager of the railroad and government departments of the **Johns-Manville Corporation**, has been elected a vice-president with headquarters at New York.

The Standard Stoker Company, Inc., New York, has purchased and taken over the patents of the **Locomotive Stoker Company** covering stokers and coal pushers. There were included also in the purchase certain assets necessary to operating under the patents, including the inventories of finished materials and goods in process and the fixed assets of the plant of the Locomotive Stoker Company at Pittsburgh. The Standard Stoker Company, Inc., will manufacture at its Pittsburgh plant and will supply without interruption, the stokers and coal pushers, and the parts for these devices, which have heretofore been manufactured by the Locomotive Stoker Company. The Erie plant of the Standard Stoker Company, Inc., will continue to supply the stokers and repair parts of the same types as hitherto.

H. H. Morgan, manager of the Pittsburgh office of the Robert W. Hunt Company, has been appointed manager of the rail department of the company, with headquarters at Chicago to succeed C. W. Gennet, Jr., resigned to accept the position of vice-president of the newly organized Sperry Rail Service Company, of Brooklyn, N. Y. Mr. Gennet's new headquarters will be in Chicago.

The Standard Steel Car Company has purchased the Illinois Car & Manufacturing Company, Chicago. P. H. Joyce, president of the Illinois Car & Manufacturing Company has been elected vice-president of the Standard Steel Car Company.

H. M. Davidson, general manager of sales of the Hayward Company, has resigned.

Lon Sloan has been placed in charge of the Chicago office of the Hendrick Mfg. Co., Carbondale, Pa., makers of interlocked steel grating.

Charles M. Hoffman has been elected vice president of the Dearborn Chemical Company, with headquarters at 310 South Mirhigan Avenue, Chicago. Mr. Hoffman has been associated with the Company since January, 1924, in the capacity of assistant to the vice president.

J. J. Melley, master mechanic of the Missouri-Kansas-Texas with headquarters at Parsons, Kans., has resigned to become assistant to the president of the Viloco Railway Equipment Company, Chicago.

The Westinghouse Electric and Manufacturing Company announces the appointment of E. C. Brandt and F. J. Shiring as assistant works managers, and J. E. Webster as chief plant engineer at East Pittsburgh, Pa., and changes simultaneously announced by E. R. Norris, general works manager, are the appointment of A. E. Kaiser as director of production for all works and S. C. Hoey as works manager of the Homewood Renewal Parts Works.

William A. Wadsworth, representative of the Oxweld Railroad Service Company, Chicago, has resigned to become representative of the Wood Conversion Company with headquarters at 101 Park Avenue, New York.

E. T. Wade representing the Franklin Railway Oil Company, Franklin, Pa., has been elected vice-president. Mr. Wade's headquarters are at Richmond, Va.

H. M. Arrick has been appointed development engineer for the American Rolling Mill Company with headquarters at Chicago. After completing a course in transportation engineering at the University of Illinois, Mr. Arrick spent several years in the construction and maintenance departments of the Pennsylvania Railroad at various points on the system. He was transportation inspector for the general superintendent of transportation at Chicago for the two years prior to his appointment with the American Rolling Mill Company. Mr. Arrick will work with the railroads and other industries in their uses of ARMCO Ingot Iron.

George T. Johnson of the manufacturing engineering and sales departments of the Buckeye Steel Castings Company has been elected third vice-president in charge of sales and engineering.

R. C. Bastress, formerly with the Fort Wayne Iron Store Company, has joined the Black & Decker organization to handle sales in Indiana and part of Michigan. L. W. Beuhausen, formerly with Slocum and Kilburn, has been employed to handle Black & Decker products through Western Massachusetts. G. N. McCarthy will represent them in Buffalo territory, taking the place of H. B. Austin who has been transferred to Chicago district.

C. D. Freeman has been made president of the Armspear Mfg. Co., New York City, vice F. D. Spear made chairman of the board; J. S. Pixley has been made vice president and treasurer, and A. G. Johnson, secretary and general sales manager.

A. N. Flora, vice-president in charge of sales of the Trumbull Steel Company, Warren, Ohio, has resigned.

Leeds, Tozzer & Co., Inc., 75 West Street, New York City, has been appointed special sales representative for the Thew Shovel Company of Lorain, Ohio, and the Universal Crane Company of Elyria, Ohio, for the Eastern Railways of the United States.

P. M. Etters, vice-president of the A. E. Lundy Company, has resigned.

Four General Electric Company men have been named members of the American committee of the World Congress of Engineers to be held in Tokio, Japan, in November, 1929. These are E. W. Rice, Jr., honorary chairman of the board; Gerard Swope, president; C. C. Chesney, vice president, and Professor Elihu Thomson, director of the Thomson research laboratory of the company. The appointments were made by Secretary of Commerce Herbert Hoover. This is the first congress of its kind ever held and, according to Baron K. Furuichi, president of the Engineering Society of Japan, is for the purpose of promoting international co-operation in the study of engineering science and problems in all its branches and stimulating a sense of brotherhood among the engineers of the world. The American committee totals 78 members and includes many nationally prominent figures.

The Fawell Engineering Company, Joseph E. Fawell, president, Pittsburgh, Pa., has been appointed exclusive representative in the Pittsburgh district for the Birdsboro Steel Foundry & Machinery Company, Birdsboro, Pa.

W. E. Grennwood, assistant manager of the railway traffic and sales department of the Texas Company has been appointed manager, succeeding William Jervis who resigned.

E. J. Fuller has been appointed assistant sales manager of the Hunt-Spiller Mfg. Corporation, Boston, Mass. Mr. Fuller formerly represented the corporation in the northwest territory, where he is succeeded by D. F. Hall.

Items of Personal Interest

F. G. Perkins is appointed division master mechanic, Brownville Division, of the Canadian Pacific Railway with headquarters at Brownville Junction, Me., vice Mr. R. V. Carleton transferred.

E. H. Roy, general master mechanic of the Seaboard Air Line, with headquarters at Savannah, Ga., has been appointed master mechanic of the Alabama division and the portion of the South Carolina division between Cayce, S. C., and Jacksonville-Baldwin, Fla., excluding Jackson and Baldwin, with the same headquarters, succeeding H. McLendon transferred.

H. H. Howard has been made roundhouse foreman of the Baltimore & Ohio Railroad at Washington, Ind., and William Kellhofer becomes night roundhouse foreman at Chillicothe, O.; G. E. Krick becomes assistant day foreman and B. A. Ryan becomes assistant night foreman.

W. J. Johnston, traveling engineer on the Iowa & Dakota division of the Chicago, Milwaukee, St. Paul & Pacific Railroad with headquarters at Mason City, Iowa, has been appointed acting master mechanic of that division, with headquarters at the same point.

C. R. Haberlin has been made traveling engineer of the Southern Pacific Company at Austin, Tex., vice C. W. Stokes, who has been promoted to general road foreman of motive power with headquarters at Houston, Texas.

James R. Hayden has been promoted to superintendent of the car department of the Missouri-Kansas-Texas, with headquarters at Denison, Texas.

L. S. Kurfess has been appointed assistant superintendent of the car department of the Erie Railroad, with headquarters at Hornell, N. Y.

L. L. Terrell, traveling fireman of the Huntington division of the Chesapeake & Ohio Railway has been promoted to the position of motive power inspector.

T. Hambley, district master mechanic of the Canadian Pacific Railway at North Bay, Ont., has been appointed assistant superintendent of motive power of the Western Lines with headquarters at Winnipeg, Man., vice A. Sturrock, has been given an indefinite leave of absence on account of illness. Edward G. Bowie, formerly master mechanic in the Ontario district succeeds Mr. Hambley at North Bay, Ont., as district master mechanic.

E. H. Schaubel has been appointed superintendent of electric activities of the Northwestern Pacific Railroad, with headquarters at Sausalito, Cal., succeeding F. T. Vanatta who retired from active service.

N. Hay, formerly assistant locomotive foreman, Smith Falls, Ont., on the Canadian Pacific Railway has been appointed locomotive foreman, White River, Ont., vice W. H. Stevenson, appointed locomotive foreman, Farnham, Que.

J. C. Harris, general road foreman of motive power and equipment of the Texas and Louisiana lines of the Southern Pacific Company, with headquarters at Houston, Tex., has been promoted to master mechanic of the El Paso division, with headquarters at El Paso, Tex., succeeding William Bleick, who has resigned.

R. J. Kelly, locomotive foreman of the Canadian National Railways at Napadogan, N. B., has been transferred in the same capacity to Edmunton, N. B.

C. K. Steins, assistant engineer of motive power of the Eastern region of the Pennsylvania Railroad, with headquarters at Philadelphia, Pa., has been appointed master mechanic of the Indianapolis and St. Louis divisions, with headquarters at Indianapolis, Ind., succeeding O. C. Wright, resigned.

R. A. McCall has been appointed foreman blacksmith of the Southern Railway at the Spencer, N. C., shops.

New Publications

Books, Bulletins, Catalogues, Etc.

Two Essays in Early Locomotive History by C. F. Dendy Marshall, M. A.—Published by the Locomotive Publishing Company, London, England. Price $3.00.

The first of these two essays consists of an account of the first hundred railway engines, based on a careful research of the material available. The author has succeeded in unearthing several engines which have hitherto been unknown to historians and illustrations are given of one or two that have not previously appeared in books on the subject; such as Wilson's "Chattaprat" and Burstal's "Perseverance," the latter which has been wrapped in mystery down to the present day.

The author shows that of the first hundred engines built up to 1831, ninety were British, two German, one or two French and six or seven American.

The second essay gives an account of early British locomotives in North America together with illustrations. Up to 1836 Britain supplied 120 locomotives to railways in the United States, after which the demand ceased altogether as we were then able to meet our requirements. British built engines furnished to Canada are also dealt with in this section.

Westinghouse Catalogue of Electrical Supplies. Publication of the 1928-1930 catalogue of Electrical Supplies of the Westinghouse Electric and Manufacturing Company has just been announced. This catalogue presents the electrical and mechanical features and application information for all supply apparatus and appliances manufactured by the Westinghouse Company, and in addition describes and illustrates a representative list of large motor and generating apparatus.

New equipment and modifications of former designs described in the new catalogue are numerous and cover a wide variety of applications, such as instruments and relays, switchgear, traction, marine, aviation, farm lighting, motor apparatus, and prime mover apparatus.

Important among new developments is a complete line of network protectors, transformers, regulators, and relays that are especially designed for low voltage alternating-current distribution networks. General adoption of the alternating-current distribution system in preference to the three-wire direct-current system is causing a steadily increasing demand for the new alternating-current equipment.

In the field of instruments and relays alone there are described in the new catalogue more than fifty new or improved designs. Among new measuring instruments described are remote indicating meters and relays, a single-phase portable standard watthour meter, portable radio meters, portable multi-element oscillographs, railroad tachometers, and special meters for marine installations. A triplex instrument for measuring current in all three phases of a line, a new vest pocket ammeter, a ratio-differential relay, and the new line of OB watthour meters and numerous other important contributions to the electrical industry are described in the new catalogue.

Among traction apparatus there are described various new designs of trolley frogs and clamps, adjustable spreaders, catenary pull-offs, catenary steady strains, dead-end clamps, messenger clinch sleeve, arc-weld flexible bonds, arcon rail bonds, and flameweld signal bonds.

Other equipment described includes new and improved airport flood-lighting equipment, farm lighting sets of improved design, portable arc-welders, a new line of small turbine-generator sets.

The new catalogue, containing approximately 1,200 pages, is the result of the combined effort to representatives of the engineering, sales and advertising departments of the Westinghouse Company to give the electrical industry the most accurate and complete information and data concerning many products. It therefore contains a treasure of information for the practicing engineer.

Mechanical Springs Bibliography. As part of its program of determining the present status of the mechanical springs art and of developing improvements through research and standardization the American Society of Mechanical Engineers, Special Research Committee on Mechanical Springs, has published a comprehensive bibliography on this subject. All phases of the design, materials, manufacture, specification, testing, and application of mechanical springs (flat, helical, spiral, conical, etc.) are covered by the bibliographical abstracts which are so cross indexed as to be of maximum usefulness. An introduction presenting in resume the historical development of mechanical springs art, is included. Copies of the bibliography may be obtained from the Publication Department of the Society, 29 West 39th St., New York.

Thomas Register of American Manufacturers. The new or 1928 edition of this valuable directory has just been issued. It gives lists of manufacturers and dealers and covers practically every article made or sold in America, giving the names and addresses of the manufacturers and an indication of the size of each plant. Lists of representative banks, commercial organizations, trade papers, trade associations, and trade names are included. The book is directly valuable to purchasing and sales departments, while indirectly it is a source of much useful information on business.

The Growth and Development of the Pennsylvania Railroad Company 1846 to 1926, by H. W. Schotter, assistant treasurer, and published by the Pennsylvania Railroad Company, Philadelphia, Pa. This is a volume of 518 pages reviewing the charter, annual reports and history of the Pennsylvania Railroad during the past 80 years, and is an important contribution to the economics of the country as a whole.

The employes of the company may obtain copies for $1.00 and the public may purchase copies from the Allen, Lane & Scott Co., Philadelphia, Pa., at $2.50.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

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New Three-Cylinder Locomotives of the N. Y., N. H. & H. R. R.

4-8-2 Type Engines Equipped With McClellon Fireboxes, Bean Cast Steel Smokeboxes and Cast Steel Cylinders

The American Locomotive Company recently delivered to the New York, New Haven & Hartford Railroad ten three-cylinder simple locomotives of the 4-8-2 type for heavy high speed freight service. These engines are equipped with the McClellon water tube boiler which was described in some detail in the February, 1926, issue of Railway and Locomotive Engineering and also with the Bean one-piece smokebox.

4-8-2 Type Three-Cylinder Locomotive Built by the American Locomotive Company for the New York, New Haven & Hartford Railroad

The cylinders are 22 in. in diameter and 30 in. stroke. A boiler pressure of 265 lbs. is employed and the driving wheels are 69 in. in diameter. At a cut-off of 82 per cent, the engines develop a tractive force of 71,000 lb.

The McClellon Boiler

The McClellon boiler was originally applied to two 2-8-2 type engines on the New Haven in 1916, but there showed some weaknesses in details of its construction, but the mechanical department officers recognizing that fundamental principles of the boiler were sound undertook to study and correct the troublesome features that they developed in service. The changes necessary were made to the two engines in 1920 and they are still in regular service. In 1924 another locomotive was equipped with the McClellon firebox in which was embodied further modification or development that were thought desirable.

As the trend in locomotive design has been to the use of higher boiler pressures, and as the water tube construction is particularly adaptable to higher pressures one of the modifications in the 1924 engine was the use of 250 lb. boiler pressure. Subsequently ten additional locomotives were equipped with the improved firebox and in these steam pressure was again increased to 265 lb. per sq. in.

In the new lot of locomotives 265 lb. pressure is also used, so that they will develop a greater tractive force than any other locomotives in use on the road.

In the McClellon type of firebox instead of the usual parallel plate for the back head sides and combustion chamber walls of water tubes are used. The roof and crown sheet of the conventional boiler is replaced with a section formed of three longitudinal drums extending the complete length of the firebox and combustion chamber and attached at their front ends to the rear tube sheet.

The tube diameters vary from 4 in. to 2 in., as may be dictated by detail designs of the back, head, and side tube arrangements, with the majority of tubes being 4 in. diameter. The tubes are received at their bottom ends into a foundation ring formed of cast steel for the firebox section and a trough for the combustion chamber section.

This tube arrangement permits the elimination of staybolts, except in the throat section and a few in the section directly below the fire door. A bracing construction carried between the foundation ring and drum is so arranged and designed as to relieve the tubes of all shocks and stresses except those arising from pressure conditions within the tubes themselves.

In the new engines, instead of the tube section being integral as on the previous locomotives, it is made in a separate piece, and joined to the outer ring by a riveted joint, its flange being turned toward the fire side. This modification will facilitate renewal of the back tube sheet and provide the necessary flexibility between the tube section and the barrel of the boiler.

Additional circulation has been provided for between the hollow mud ring and the barrel, through two circulating pipes extending from each front end of the mud ring, and connecting to the barrel just ahead of the back tube sheet. These additional circulating pipes are to improve the circulation. The construction is such that boiler circulation is freer and more positive than in the usual design of boiler. This fact is borne out in actual service

Type of locomotive	4-8-2
Service	Fast freight
Cylinders, diameter and stroke	3 cyl., 22 in. by 30 in.
Valve gear, type	Walscbaert
Valves, piston type, size	11 in.
Maximum travel	6 in.
Outside lap	1 1/16 in.
Exhaust clearance	3/16 in.
Lead in full gear	¼ in.
Cut-off in full gear, per cent	85
Weights in working order:	
On drivers	260,000 lb.
On front truck	58,500 lb.
On trailing truck	60,500 lb.
Total engine	379,000 lb.
Tender	288,500 lb.
Wheel bases:	
Driving	19 ft. 9 in.
Rigid	12 ft. 2 in.
Total engine	42 ft. 3 in.
Total engine and tender	85 ft. 4 in.
Wheels, diameter outside tires:	
Driving	69 in.
Front truck	33 in.
Trailing truck	44 in.
Journals, diameter and length:	
Driving, main	11½ in. by 14 in.
Driving, others	10½ in. by 14 in.
Front truck	6½ in. by 12 in.
Trailing truck	9 in. by 14 in.
Boiler:	
Type	McClellon
Steam pressure	265 lb.
Fuel, kind	Bituminous
Diameter, first ring, inside	79⅝ in.
Firebox, length and width	120 in. by 85 in.
Arch tubes, number and diameter	4—3 in.
Combustion chamber length	68 in.
Tubes, number and diameter	29—2¼", 14—3½"
Flues, number and diameter	170—3½ in.
Length over tube sheets	19 ft. 8 in.
Grate area	70.8 sq. ft.
Heating surfaces:	
Drums	96 sq. ft.
Combustion chamber tubes	95 sq. ft.
Firebox side tubes	145 sq. ft.
Firebox back tubes	35 sq. ft.
Firebox back section	2 sq. ft.
Arch tubes	27 sq. ft.
Firebox tube sheet and throat	51 sq. ft.
Total firebox	451 sq. ft.
Boiler tubes and flues	3,634 sq. ft.
Total evaporative	4,085 sq. ft.
Superheating	1,756 sq. ft.
Combined evaporative and superheating	5,841 sq. ft.
Tender:	
Style	Water bottom
Water capacity	16,000 gals.
Fuel capacity	18 tons

and demonstrated by the more uniform and quicker warming up of these boilers when cold, and the lesser accumulation of mud and scale in those of the firebox that are normally subject to deposits of this kind.

A further change has been made in the method of lagging the firebox. For insulation purposes and prevention of air leakage into the firebox, as well as general protection, the entire tube assembly is enclosed with Ascoloy steel sheets, a material designed to withstand high temperatures. These sheets completely seal the firebox. Lagging is applied outside the sheets and a jacket over the lagging, so that the external appearance of the firebox is no different than with the usual staybolt type of construction.

Cast Steel Smokebox and Cylinders

There is a generous use of cast steel where this could be substituted for fabricated sections throughout the construction of the new locomotives. Cast steel has been used for the smokebox arrangement and for the cylinders. In the former, air leaks are appreciably reduced, and in the latter, an approximate saving in weight of 6,000 lb. is effected.

The cast steel smokebox was designed and patented by W. L. Bean, mechanical manager of the N. Y., N. H. & H. R. R. In the single casting are combined all the auxiliary parts, such as steps, steam pipe flanges, feed water heater brackets, supports for outside throttle, smokebox brace lugs, front door hinges, etc. This construction eliminates air leaks and reduces to a minimum the number of parts in the smokebox, reducing maintenance costs. The smokebox also includes lugs at the front and back which are fitted to flanges on the cylinders which are further locked to the smokebox by welded flanges and keys. This arrangement will further reduce maintenance costs as it insures constant alinement of the frames, and keeps the wheels, boxes, guides, valve motion, etc., in correct position at all times.

The running gear of the new locomotives is the same as on the previous engines of the same type. The Commonwealth Steel engine truck is used. Lateral motion boxes are fitted to the front driving wheels. The main rods are fitted with solid bushings on the front end and floating bushings on the back end. In accordance with the practice of the road, the side rods have floating bushings in the middle connection. The delta type of trailing truck of the Commonwealth Steel Company is also used.

Other specialties employed include the Elesco feedwater heater, automatic train control, force feed lubricators, air operated whistle, automatic bell stops, soot blowers, stokers and multiple throttles. The stoker engine is mounted on the front of the tank. A folding door in the side of the tank provides access to the engine compartment for inspection and repairs.

A feature of the locomotives is the compact arrangement of all parts within the cab. The handles of all the principal valves are brought together on a line across the backhead, with the name of each valve stamped on metal plates immediately next to the valve handles. The placing of the mechanical lubricators at the forward end of the locomotive results in giving additional room in the cab.

The tenders have a capacity of 18 tons of coal and 16,000 gallons of water.

Further particulars in regard to the locomotives are given in the accompanying table.

Chimes on Locomotives

The Frisco System is installing on its locomotive melodious four-note compressed air chimes, termed Volitones, which it is said can be heard twelve miles away.

The chimes are replacing the single-note steam whistles heretofore used on this railway and general on most other American railroads. The chimes might be interpreted as saying courteously, "Won't you kindly move from our right of way?" in contrast to the old-style whistles which seemed to yell, "Get off the earth!"

The Volitone is comprised of a quartet of horns, mounted on the roof of the locomotive cab, two of the horns pointing forward and two rearward. When the Volitone valve is released by the engineer an air pressure of eighty pounds to the square inch is released against a thin metal diaphragm in the mouth-piece of each horn. Reasons for the change to Volitones are given by the Frisco as follows: Greater efficiency in averting grade crossing accidents, reduction of disturbance to people residing near the right-of-way, and compassion for engine crews. The Frisco is one of the first American railroads to adopt the compressed air chime as standard locomotive equipment.

The Past and Future in Railway Efficiency

By B. W. E. Symons

In the December, 1922, issue of Railway and Locomotive Engineering there appeared an article in answer to the unjust criticism of a writer, who either through ignorance or a desire to farther propaganda detrimental to railway interests, had in substance accused them of about all the acts of ommission and commission embraced in the category of inefficiency or mismanagement.

The article referred to not only showed clearly that railway officers had been falsely accused, but that they were entitled to much credit for having already accomplished, much if not all the things they were condemned for failing to do.

There was then, and probably there are now, certain instances where improvements can and should be made, but these are exceptions to the general high standards maintained in the design and operation of our modern transportation units.

A rather extensive article appeared in the pages of this paper in the issue for February, 1924, in which various phases of operating economies was dealt with. Particular attention was directed to fuel economy, which

Railway	Lbs. Coal per 1,000 ton miles 1922	Lbs. Coal per 1,000 ton miles 1926	Saving in Coal per 1,000 ton miles
Atlantic Coast Line	133	122	11
Santa Fe	145	119	26
B. & O.	190	166	24
Boston & Maine	185	140	45
Cent. New Jersey	207	163	44
St. Paul	171	141	30
C. B. & Q.	185	141	44
C. & N. W.	184	138	46
Rock Island	201	147	54
Ches. & Ohio	150	101	51
D. & H.	228	156	72
D. L. & W.	216	153	63
D. & R. G.	276	195	81
Erie	154	128	26
Gt. Northern	183	128	55
Ill. Cent.	154	133	21
L. & N.	193	163	30
Lehigh Valley	217	153	64
Mich. Cent.	136	117	19
Mo. Pacific	182	129	53
Norfolk & Western	238	142	96
Penn. System	170	160	10
Reading	190	160	30
Southern Pacific	159	111	48
Southern Railway	218	159	59
Texas & Pacific	189	111	78
Union Pacific	186	115	71
Wabash	165	131	34
Wheel. & L. Erie	210	163	47

of course, not only embraces locomotive management, but many other features of railway operation. Attention was also directed to the wonderful opportunities existing for still greater economy in certain items of expense. A tabulation was shown of 22 selected items on 40 of our leading railways, with comments on what was thought the most important to be selected for improvements.

The tabulation above referred to was so prepared as to be easily understandable by all who have to do with locomotive efficiency and fuel economy. Consideration of locomotive design in connection with fuel economy was referred to and indicator cards from locomotives at high speeds handling heavy passenger trains were shown.

It was predicted that wonderful strides would be made in higher efficiency, particularly in the item of fuel economy, and although the prophecy has in a large measure become true, yet there is still room for great improvement in a general way. In the matter of excessive back pressure on pistons, millions of dollars are *still being wasted*, and only slight efforts being made to apply a practical and effective remedy.

The saving in pounds of coal per 1,000 ton miles in freight service is one of the oustanding features in a review of railway economic achievements. In order that this may be more fully realized the amount of saving on a selected number of lines is here shown for comparative purposes:

The indicated savings in fuel per 1,000 ton miles on only 29 railways, ranging as it does from 10 lbs. to as much as 96 lbs., means actual saving of millions of dollars. Similarly, savings on other lines not referred to above or in the tabulation on page 74 would amount to many millions of dollars more.

This point is at once made clear by a display of the consumption of fuel per 1,000 ton miles on all railways by months and the average for the years 1922 to 1926 and compared with that for the years of 1926 and 1927 as shown in the following table.

Months	1927	1926	Average 1922 to 1926	Savings in 1927
Jan.	153	158	173	20
Feb.	142	153	169	27
March	136	150	161	25
April	132	140	151	19
May	125	128	141	16
June	121	124	135	14
July	118	121	134	16
Aug.	118	121	134	16
Sept.	119	125	138	19
Oct.	124	130	145	21
Nov.	135	143	155	20
Dec.	148	153	166	18
Average				

It is quite clear that the railway officers and employees have not tackled this problem in any half hearted manner, but with a determination to get results.

The reduction in pounds of coal per passenger car mile it will be noted has been much reduced over the same period of time, although the actual savings effected would not indicate the same money yield as from what has been accomplished in freight service. It must also be remembered that this is not an unfailing or arbitrary yard stick by which to measure economy, due to the fact that local operating conditions rather than high standards of service influence or control this item of expense. The pounds of coal per passenger car mile monthly for 1926 and 1927, and the average for the years 1922 to 1926 is shown on page 65.

	1926 Name of Railway	Miles of Road and Earnings Per Mile: Miles of Road	Earnings Per Mile	Number of Locomotives—Average Tractive Power—Cost of Repairs Per Year and Per Mile—Mileage Per Day: Number of Engines	Average Tractive Power	Annual Cost of Repairs	Cost Mile Run	Miles Per Day: Frt.	Pass.	Freight Statistics: Aver. Tons Per Train	Speed Miles Per Hour	Car Miles Per Frt. Car Day	Lbs. Coal Per 1,000 Ton Miles	Cost of Coal, Ton	Revenue Per Train Mile	Per Cent of Freight Revenue	Passenger Statistics: Pass. Cars Per Train	Lbs. Coal Per Pass. Car Mile	Revenue Per Pass. Train Mile	Average Number Pass. Per Train	Per Cent Pass. Rev.	Material and Supplies Per Mile Road	Operating Ratio Per Cent, 1926
1	At. Coast Line	4,996	$19,689	938	32,750	$6,337	.227	77	140	566	12.0	30.5	122	$3.26	$6.61	70.0	7.4	12.6	$2.31	53.8	30.0	$1,741	72.8
2	A. T. & S. Fe	10,275	22,088	1,757	46,088	7,831	.251	102	211	690	13.6	37.7	119	4.49	7.87	74.0	8.3	14.8	2.59	61.9	26.0	2,299	64.3
3	B. & O.	5,288	47,690	2,469	49,496	8,794	.305	90	167	918	10.2	30.0	166	1.81	8.56	82.4	6.9	17.8	2.01	48.8	17.6	3,666	73.8
4	Bess. & L. E.	228	74,429	173	46,416	6,981	.382	89	89	1,667	12.3	16.0	119	2.42	11.84	97.0	3.2	....	.77	18.5	3.0	3,693	58.1
5	Boston & Maine	2,111	37,350	933	30,424	6,589	.301	73	104	544	10.6	21.4	140	4.57	8.89	63.5	5.7	15.8	3.83	78.6	36.5	3,303	76.4
6	Cent. of N. J.	691	86,507	567	36,776	6,842	.293	61	105	895	9.3	14.1	163	3.55	14.18	78.0	4.9	28.0	2.57	113.0	22.0	5,777	76.4
7	Chicago G. W.	1,496	16,951	272	39,589	7,325	.235	111	220	665	13.0	42.9	139	3.10	6.04	77.5	6.1	....	1.60	36.3	22.5	991	79.0
8	C. M. & S. P.	11,201	14,342	2,004	37,932	5,812	.227	86	158	712	12.3	30.4	141	2.51	6.53	77.5	6.3	17.6	1.76	38.6	22.5	1,255	80.0
9	C. B. & Q.	9,392	17,155	1,944	37,762	5,540	.219	74	143	794	12.8	36.0	140	2.55	6.53	75.3	6.7	16.7	1.90	48.2	24.7	1,493	72.2
10	C. & N. W.	8,461	18,245	1,996	35,514	6,372	.261	81	132	580	12.4	25.2	138	2.38	6.09	71.4	6.6	18.9	2.10	56.6	28.6	1,597	78.1
11	C. R. I. & P.	8,020	17,188	1,555	37,013	8,675	.255	96	169	553	12.8	32.0	147	2.97	5.88	74.0	6.5	17.2	1.98	50.1	26.0	1,293	74.5
12	C. & O.	2,651	50,627	1,041	53,494	10,356	.359	88	143	1,414	10.7	54.4	101	1.71	8.04	89.0	5.8	18.9	2.05	47.3	11.0	2,327	67.9
13	Del. & Hud.	882	52,585	461	43,182	8,994	.347	107	149	886	11.9	33.9	156	2.66	8.92	86.3	5.7	22.0	2.28	47.9	13.7	3,985	75.1
14	D. L. & W.	990	89,991	751	39,007	7,477	.266	99	131	784	11.9	33.8	153	3.24	9.53	73.4	7.6	20.3	3.09	110.9	26.6	3,873	70.2
15	D. & R. G.	2,562	13,278	489	41,425	5,309	.257	60	123	709	10.3	22.0	195	2.29	8.70	79.1	7.2	19.9	2.18	59.5	20.9	1,173	72.7
16	D. T. & Iron	486	26,476	84	37,545	17,504	.552	128	137	674	11.3	36.7	111	3.37	9.03	97.7	2.9	....	.69	13.4	2.3	1,551	68.2
17	Erie	2,446	54,065	1,223	46,903	7,349	.346	89	132	965	11.5	33.2	128	2.95	8.47	81.3	8.3	19.6	2.38	77.3	18.7	4,096	79.0
18	Great Nor.	8,164	14,336	1,306	44,098	4,418	.207	67	121	980	11.6	27.9	128	3.88	9.16	79.5	6.4	18.5	1.70	36.8	20.5	1,205	64.1
19	Hocking Val.	349	56,087	136	50,207	9,237	.234	100	146	1,607	11.1	29.7	124	1.85	10.30	87.0	4.0	....	1.67	38.0	13.0	2,543	70.7
20	Ill. Cent.	6,585	28,798	1,962	41,363	7,712	.258	89	130	754	12.8	42.1	133	2.25	6.22	77.7	6.5	18.9	1.94	51.0	22.3	2,113	76.8
21	L. & N.	5,034	22,322	1,359	39,363	9,369	.256	110	180	656	11.4	31.4	163	1.85	5.34	79.3	6.2	20.9	2.11	51.0	20.7	3,030	76.4
22	Lehigh Val.	1,364	58,994	927	42,991	7,763	.258	73	121	822	13.1	29.1	153	3.45	9.20	83.0	8.0	17.2	2.40	56.8	17.0	4,506	75.8
23	Mich. Cent.	1,856	51,468	716	40,277	7,390	.236	107	231	662	14.2	30.2	117	3.78	9.18	67.5	9.3	11.7	3.64	82.4	32.5	3,320	68.0
24	Mo. Pac.	7,348	18,237	1,227	39,510	8,764	.273	89	158	717	12.6	39.8	129	2.78	6.52	80.5	6.3	17.3	1.67	37.5	19.5	1,969	76.8
25	Nor. Pac.	6,682	14,568	1,242	39,829	3,963	.186	72	122	789	12.7	29.4	142	3.16	7.60	78.3	6.9	22.2	1.81	42.3	21.7	1,701	70.1
26	New York Cent.	6,928	57,669	3,664	44,084	7,393	.259	95	173	926	11.9	30.1	124	2.68	8.66	62.2	8.1	12.9	3.18	80.2	37.8	5,127	74.8
27	Nor. & West.	2,241	53,719	941	57,601	9,948	.403	87	132	1,572	12.5	43.6	142	1.75	9.68	90.3	6.4	23.0	2.02	45.1	9.7	6,115	59.2
28	N. Y. C. & St. L.	1,692	32,478	502	38,435	6,914	.220	115	211	672	13.4	44.4	115	3.14	6.49	93.1	5.1	17.2	1.17	26.7	6.9	2,573	72.8
29	New Haven	1,912	70,457	1,007	35,986	9,043	.346	71	132	588	11.6	17.0	128	4.43	11.64	51.3	7.1	13.3	4.55	138.4	48.7	7,583	73.7
30	Pere Mar.	2,286	20,385	448	34,997	6,094	.224	89	131	604	11.6	28.8	115	3.45	7.31	85.1	6.5	14.5	2.24	47.8	14.9	1,109	69.6
31	Penn. System	10,906	66,271	7,001	48,000	8,797	.308	78	156	897	10.6	24.5	136	2.10	8.46	69.5	7.2	17.9	2.87	73.1	30.5	5,113	77.6
32	Phila. & Read.	1,140	86,517	775	41,548	6,118	.232	89	98	943	10.9	23.8	160	3.02	10.47	85.4	4.7	27.2	2.01	66.0	14.6	6,561	74.0
33	Pitts. & L. E.	231	147,784	292	46,451	5,626	.253	99	149	1,500	10.5	11.9	90	2.30	18.11	88.0	5.1	27.9	2.36	88.0	12.0	13,492	80.5
34	Seaboard	4,033	16,997	709	38,864	5,788	.197	81	135	592	11.2	30.9	139	3.04	6.89	72.9	7.1	14.1	1.86	40.1	27.1	1,868	73.5
35	So. Pac. P. S.	8,929	23,706	1,750	41,931	6,975	.225	94	191	693	12.0	38.7	128	4.49	8.28	71.3	8.7	12.4	2.28	65.8	28.7	3,553	68.4
36	Southern	8,140	24,966	2,262	42,355	6,676	.247	72	138	559	12.9	32.0	159	2.13	5.78	73.1	6.7	17.5	2.30	54.3	26.9	2,015	69.2
37	Tex.-Pacific	1,954	18,146	334	40,251	8,322	.312	74	159	579	12.8	33.9	111	4.50	7.30	74.9	7.6	12.7	2.62	60.5	25.1	2,063	74.7
38	Union Pacific	3,714	30,832	876	48,068	9,332	.293	112	247	795	16.5	61.5	115	2.85	7.18	76.9	8.6	13.3	1.94	47.2	23.1	2,133	65.0
39	Wabash	2,524	28,402	699	39,724	7,335	.248	97	194	683	14.5	42.6	131	2.30	6.44	79.8	6.4	15.5	2.04	50.2	20.2	2,136	73.2
40	Wheeling & L. E.	512	40,903	200	47,251	7,756	.378	70	88	1,024	7.8	18.3	163	1.98	11.20	91.5	4.2	....	1.12	29.8	8.5	1,864	71.6
	Total or averages	166,700	41,067	48,992	41,862	7,620	.280	88.5	149	840	11.9	31.7	123	2.92	8.47	78.5	6.4	17.8	2.16	56.7	21.5	3,170	72.4
	Total or averages, U. S.	......	36,907	......	......	.....	....	85	152	772	11.9	39.4	137	2.63	7.58	....	...	....	2.33	....	....	.....	....

A Tabulation for Comparative Purposes, Etc., Showing the Mileage, Earnings Per Mile of Road, Engines in Service, Average Tractive Power, Annual Costs of Repairs, with Freight and Passenger Statistics, and Operating Ratios for Forty Principal Railway Companies of the United States, with Totals and Averages

Months	1927	1926	Average 1922-1926	Saving in 1927
Jan.	17.4	17.7	19.2	1.8
Feb.	16.8	17.6	19.1	2.3
March	16.3	17.1	18.3	2.0
April	15.6	16.2	17.1	1.5
May	15.0	15.1	16.3	1.3
June	14.4	14.7	15.5	1.1
July	14.0	14.3	15.3	1.3
Aug.	14.1	14.3	15.4	1.3
Sept.	14.2	14.6	15.7	1.5
Oct.	14.9	15.4	16.6	1.7
Nov.	15.6	16.5	17.4	1.8
Dec.	16.6	17.0	18.0	1.4

The savings indicated are really of greater moment than the actual figures would convey to the average mind, but when properly applied to our passenger train statistics will reflect savings that run into millions of dollars.

The true significance of the foregoing figures can best be understood when we recall that our class one railways in 1926 derived operating revenues of approximately $6,382,939,546
With operating expenses of 4,669,336,736

Net return from operation $1,713,602,810
The locomotive fuel expense in 1923 was. .$542,305,784
In 1926 it was only 417,180,674
Reduction over 1923 ....$125,125,110

It must be borne in mind, of course, that the total drop in locomotive fuel expense is not all due to economy in its use. The cost of fuel is no small factor and as there has been a material reduction in price, this factor must be taken into account.

There are two other items of more than ordinary interest in economy of operation that does not to any appreciable extent affect fuel economy. These are the amount of material on hand and the average car miles per freight car per day.

Materials on hand has been reduced many millions of dollars and could with safety be further reduced, while the wonderful increase in freight car miles per day shows great economies are being effected in that item.

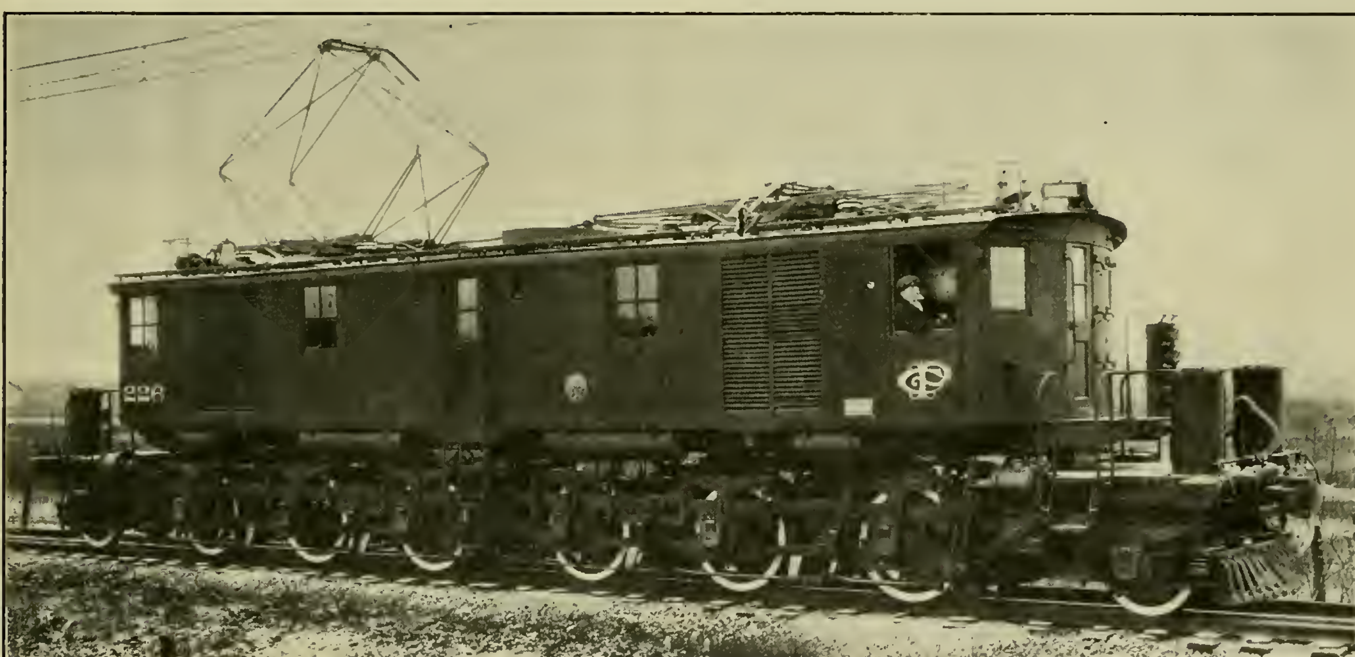
The freight car miles per day, however, should not be used as a criterion or yard stick to measure standards of operating effciency without a thorough knowledge of all factors involved. The through transcontinental lines in the sparsely settled western country show a much higher average car mileage than lines in the congested eastern country, that may be equally as well managed, but in some instances get only about one-half the mileage, local conditions being the controlling factors.

Again the wonderful increase in average miles per day for freight and passenger locomotives has been a wonderful factor in fuel economy, as the overhead stand-by and terminal fuel costs have not only been materially reduced throughout, but in some instances cut in half.

New Locomotives for Paulista Railway

Three new electric locomotives, the largest and most powerful units ever operated on 3,000 volts, direct current, in any country outside the United States have been put into express passenger service by the Paulista Railway of Brazil. This company electrified part of its main line in 1921 and the results have been so successful that three subsequent extensions have been made, bringing the length of the electric zone up to about 180 miles, and the total number of 3,000-volt electric locomotives up to 24.

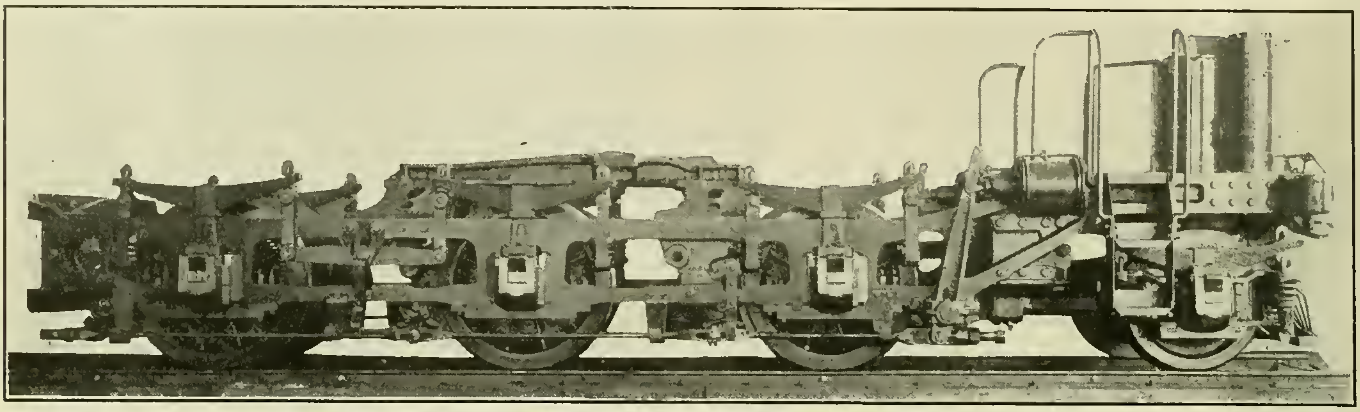
The complete locomotives, including both mechanical and electrical parts, were built by the General Electric Company at its plant in Erie, Pennsylvania. They are of the geared motor type, and each locomotive has two driving trucks articulated together, and a cab mounted on center plates. Each driving truck has three individually driven axles and is provided with a single-axle, radius-bar guiding truck.



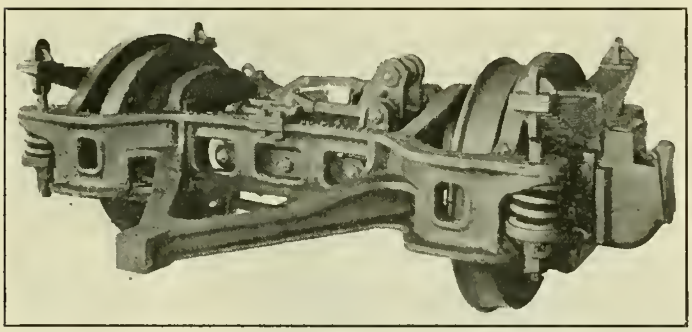
Electric Locomotive of the Paulista Railway, Brazil

Direct current is obtained from an overhead trolley at 3,000 volts and is supplied to the traction motors which are wound for 1,500 volts and connected, each pair in series, across the line. Locomotive speed is controlled by series-parallel connections of the motors using accelerating rheostats, and by reductions in motor field strength.

Control is of the standard electro-pneumatic type arranged for non-automatic, multiple-unit operation. Current is collected by means of two air-raised trolleys, either of which has sufficient capacity to supply the entire locomotive. Each engineman's compartment contains a master controller for governing acceleration and speed, a controller governing the traction motor fields and for regenerative braking and two other controllers, one the selector for regenerative braking and the other, the reverse handle. Control couplers are provided by means of which two locomotives can be operated from a single controller.



Side View of No. 1 Truck of Electric Locomotive of the Paulista Railway



Three-Quarter Rear-End View of Railway Guiding Truck of Locomotive of Paulista

Each locomotive is equipped with a dynamotor which supplies 1,500 volts for the operation of auxiliaries. The auxiliaries include a small lighting generator; two air compressors for operating brakes, bell, whistle, etc.; two exhausters for the vacuum brakes; two motor-operated blowers for ventilation, and a motor-generator set for field excitation during regeneration.

The principal locomotive data are as follows:

DIMENSIONS:

Gauge	5 ft. 3 in.
Total weight	294,000 lb.
Total weight on drivers	237,000 lb.
Weight per driving axle	39,500 lb.
Weight per guiding axle	28,000 lb.
Total wheelbase	51 ft. 0 in.
Rigid wheelbase	13 ft. 6 in.
Diameter of driving wheels	46 in.
Diameter of guiding wheels	36 in.
Length overall (inside knuckles)	58 ft. 8 in.
Width over cab	10 ft. 0 in.
Height over pantograph (locked down)	14 ft. 3 in.
Number of motors	6
Type of motors	GE-278-B
Minimum radius of curvature	300 ft.

ELECTRICAL CHARACTERISTICS:

Voltage at trolley (d. c.)	3,000
Tractive effort, one-hour rating	30,600 lb.
Horsepower, one-hour rating	2,725
Speed at one-hour rating, full field	33.3 m.p.h.
Tractive effort, continuous rating	25,900 lb.
Horsepower, continuous rating	2,405
Speed at continuous rating, full field	34.8 m.p.h.
Tractive effort at 30 per cent coefficient of adhesion	71,100 lb.
Maximum operating speed	62.5 m.p.h.
Gear ratio	77/31
Control voltage	65
Type of control (non-automatic)	Electro-pneumatic Multiple-unit

What a Mile of Railway Does in a Day

The average mile of railway line in the United States last year handled seven passenger trains and seven freight trains each day, according to an analysis just made of operating statistics covering the year 1927.

In dealing with railway traffic figures running into hundreds of millions and billions, it is sometimes difficult to visualize the amount of work which is performed, on the average, by the units of the railway plant. The following figures, therefore, have been prepared on the average daily operations of each mile of railway line.

Seven Freight Trains Daily Composed of 325 Cars

In the seven freight trains which passed each day over this average mile of railway there were 325 freight cars, of which 205 were loaded and 120 empty. In the loaded cars was freight weighing, roughly 5,600 tons, while the total weight passing over this mile of line, including freight, locomotives and freight cars, was 14,400 tons.

The seven daily passenger trains which ran over this average mile included 46 passenger train cars and carried a total of 416 passengers.

How Revenues Are Divided

The daily gross revenues earned by this average mile of railway line amounted to $72. The average direct operating expenses consumed 74 per cent of these total earnings, or $53 daily. Next, a total of $4 a day was paid by this average mile of railway to local, state and national tax collectors.

After the payment of certain other expenses, including rental charges for property belonging to others, the average daily net earnings of this typical mile of railway line amounted to $13. This daily average net earning figure of $13 amounted in a year to a return of approximately 4½ per cent on the average railway property investment per mile.

First All-Steel Passenger Cars in South America

Built by the American Car and Foundry Company for the Paulista Railroad

The American Car and Foundry Export Company has made a unique shipment of twenty-two all-steel passenger cars on board the SS. Belpariel from the Commissioners' Dock, Wilmington, Del., to the harbor of Sao Paulo, Brazil, where they will go into the service of the Paulista R. R., one of the most modern roads in South America. This is the first all-steel passenger equipment installed on South American Railways.

Representatives of the car company went to Brazil to obtain information in regard to the railway's requirements for passenger equipment cars. The standards of the railroad up to that time had been all wood cars and some cars having steel underframes and wood superstructures built principally by Europe. The progressive management of the Railroad, after consultation with the A. C. F. engineers, decided to purchase all steel equipment so as to reduce to a minimum accidents from wrecks and fires and consequent loss of life, which hazards are always present with the use of wooden cars.

Subsequently, the Paulista Railway Company placed an order for 7 first-class coaches; 6 second-class coaches; 3 parlor cars; 2 dining cars; 2 mail cars and 2 baggage cars. These cars were built at the Berwick, Pa., works of the American Car and Foundry Company and the train complete was run to the company's yards at Wilmington, Del., whence it was shipped for Brazil.

The cars are of all-steel construction throughout and conform in all essential construction to cars operating on first class railroads of this country. The only variations are as to gauge of track, type of couplers, buffers and brakes, which items of course are constructed to meet the railway company's standard requirements. The gauge of track is 5 ft. 3 in. The couplers are a transition type consisting of an automatic head hinged so as to drop down out of the way when a hook housed within the coupler head is used with the railway's present screw type of coupling. American standard central buffing arrangement is provided for use with the automatic couplers; also side buffers, hinged to drop down out of the way when not used, are provided to operate in conjunction with the screw type of coupling. The reason for providing two types of coupling and buffing arrangements is that the railway is now in the transition period and is gradually changing to the exclusive use of automatic couplers as used in this country.

Vacuum brakes of European manufacture are provided and the foundation rigging is so arranged that automatic air brakes of similar type to that used in this country may later be applied with the least possible change in details.

The coaches and parlor cars are 70 ft.-0 in. long over body corner post and 79 ft. 5⅞ in. over buffer plates. The first-class coaches have a seating capacity of 80, second-class coaches 98 and the parlor cars 18 in the main compartment and 6 each in a reserved compartment at one end of car and a smoking compartment at the other end. Seats in the first-class coaches are reversible type rattan covered, seating two passengers each. In the second class coaches they are reversible wood slat type, seating three passengers each on one side of the aisle and two each on the other. The parlor cars are provided with de luxe type leather-covered revolving chairs in the main compartment, and movable chairs and stationary seats covered with the same kind of leather in the two end compartments.

First All-Steel Passenger Train Shipped to South America Leaving Plant of the American Car and Foundry Company, Berwick, Pa.

The dining cars are 78 ft. 8 in. long over body frame and 82 ft.-0-⅞ in. over buffer face plates. The seating capacity is 36. The conventional pantry and kitchen equipment as well as buffets, refrigerators, lockers and cabinets, etc., as used on American dining cars are provided.

The postal and baggage cars are 60 ft.-9½ in. long over body frames and 64 ft.-2⅜ in. over buffer face plates. The postal cars are provided with Railway Mail Service standard equipment as specified for full 60 ft. cars. The baggage cars have two 6 ft. doors on either side and a separate conductor's compartment in either end.

All passenger cars have composition floors and the mail and baggage cars double wood floors. All cars are full vestibuled and as they will operate where all stations are provided with high platforms the regulation trap doors are unnecessary, although small ones are provided to uncover the steps when necessary to enter the cars when not standing on the high platforms.

Electric lights are used on all cars, generation being supplied by axle light equipment and cars are amply provided with ventilators, electric fans and thorough insulation to protect the passengers against the heat of the climate in which they will be operating.

The interior finish of all cars is of steel throughout, except the head-linings and wainscotings which are of fireproof agasote. All cars have Monitor decks and roof sheets which are of copper bearing steel sheets riveted

Interior of All-Steel Parlor Car

in place to the roof framing members. All doors are of copper bearing steel which is another American Car and Foundry product.

All cars are provided with conventional toilets and lavoratories including flush hoppers, wash stands and other usual equipment as used on cars on American railroads. Modern sanitary water coolers complete with filters and automatic shut-off are furnished of a type having separate compartments for ice and water together with the usual sanitary drinking cup dispensers.

The first-class coaches, parlor car and dining cars have 6 wheel trucks and the second-class coaches, baggage and postal cars have 4 wheel trucks. All trucks have clasp brakes and wheels are 38 in. diameter, steel-tired, of a type that is Railway Company's standard.

The interiors of the cars are attractively painted and grained to imitate jacaranda, a wood native to Brazil. Ceilings are painted white. Headlinings and frieze boards are neatly striped, and simple but effective decorations are applied to all pier panels. The exteriors of the cars are painted olive green and Railway Company's monogram is applied to each side of the cars. The cars are also lettered in Portuguese to indicate the respective type, various compartments, etc.; in general, about as per the standard practice in this country.

The Paulista Railway on which these cars will operate is one of the most progressive roads in South America. It reaches into the heart of the coffee district and extends from the interior, where it is fed by numerous narrow gauge branches, to the city of Sao Paulo, where it connects with the Sao Paulo Railway over whose tracks freight cars are transported to the coast at the city of Santos. Paulista passenger cars run to Sao Paulo only.

The main line of the railway over which these cars will operate is up-to-date in every respect including rock ballasted track, automatic signal devices, etc. The motive power is furnished by electric locomotives operated through overhead transmission, and the present facilities combined with the installation of these modern all-steel cars will provide a passenger transportation that will be the equivalent of that furnished by our best railroads in these United States.

Study Problem of Expanding Facilities

To meet the steadily growing traffic and the almost prohibitive cost of expansion, particularly in the larger cities, double-decking and probably triple-decking of railway facilities is a possibility of the future, according to D. J. Brumley, Chief Engineer, Chicago Terminal Improvements of the Illinois Central Railroad, at the recent annual meeting of the American Railway Engineering Association of which he is president.

"It is clear," said Mr. Brumley, "that the need for new rail lines and extensions is almost satisfied and it would appear that the work for the immediate future would be the orderly development of rail lines in existence. The railways are susceptible of great improvement, such as reduction of grades, multiple tracking, elimination of curvature, construction of diversion lines around congested centers, shortening of lines and the extension and use of block signals.

Developments of Motive Power

"Electrification no doubt will be extended since it has great operating advantages over steam under given conditions, such as density of traffic, heavy grades, feasibility of operation in congested terminals, a commutation service where frequent stops are made and operation under covered areas where airtight developments are justified. The steam locomotive, or some other form of self-contained unit, for many purposes has operating advantages, and the immediate future, at least, has many possibilities for its improvement and the development of internal combustion and storage battery locomotives.

Ample Funds Will Be Needed

"Freight loading increased from 583,000,000 tons in 1900 to 1,363,000,000 tons in 1920 or 133 per cent in 20 years. Passenger trains are pulled at higher rates of speed by locomotives with much greater wheel loads. If the next score of years shows a continuance of the increase in freight loading and speed, there will need to be large sums expended to keep capacity of rail lines in step with traffic. The burden of providing a suitable and adequate instrument for meeting the future needs of railway transportation rests with the members of this Association, the scientists, and the manufacturers interested in improving this form of transportation service."

Oil-Electric Locomotive Economical in Service

Evidence of the economy of the oil-electric locomotive is found in a recent analysis made by the Reading Railroad of the operation of a 60-ton, 300-horsepower locomotive of this type over a period of 256 days. During this time the locomotive traveled 28,038 miles covering 4,673 hours of service. The total maintenance cost during this period was $2,036.78.

A steam engine, employed in the same service, cost $3,364.56 to maintain for an equal number of working hours during an equal period of time. It comsumed $4,808.52 worth of fuel and lubricating oil as compared with but $1,703.23 for the oil-electric locomotive.

The oil-electric locomotive is equipped with a 300-horsepower, Ingersoll-Rand oil engine driving a standard General Electric generator and supplying power to four 95-horsepower General Electric traction motors. Standard type M control is used.

The Mechanical Engineer in the Railroad and Railroad-Supply Industries

Abstract from a Report Presented to the American Society of Mechanical Engineers

By Marion B. Richardson, New York, N. Y.

It is the belief of the Railroad Division's Sub-Committee on Professional Service of the A. S. M. E., that the opportunities afforded the mechanical engineer in the railroad and railroad-supply industries are equal to those afforded in any industry. This belief is based on several facts which are later discussed in this report, probably the most significant of which is that competition with other college-trained men is not as great as is the case in many other industries. A study of the careers of 150 railway officers holding positions from president down to master mechanic, show that only 43.7 per cent are college graduates. The railroad-supply industry, however, presents a slightly different ratio, 63.3 per cent being college graduates out of a total of 113 railway-supply company officers ranging from president down to sales representatives. In both cases the officers were selected at random with the primary object of obtaining as accurate a picture as possible of the competition to be expected by the mechanical engineer in both industries.

These figures are also significant of one other important factor pertaining to the success of the individual in railroad and railroad-supply work. Knowledge of railroading, individual adaptability, practical experience and a willingness to work appear to have considerably more value in the mind of the average executive than college education.

It is the general practice of the railroads to extend preferential consideration to college graduates. It is expected that the college graduate will start on an equal footing with the non-college man and show his worth in actual service. In other words, the college man is worth comparatively little to a railroad company until he has had considerable practical training and experience. This, in the main, is also true of most industries employing technical graduates.

How to Use the Information Contained in This Report

Much of the information contained in this report was obtained by studying and analyzing the careers of railroad and railroad supply officers, published in the railway-trade press. This was also supplemented by writing direct to the various companies for additional information. The Sub-Committee on Professional Service has assumed from the beginning of its work on this project that what the young mechanical engineer wants and should have is facts, not advice. He ought to have a fairly accurate picture of the industry he expects to work in before he enters it. Such a picture is not difficult to obtain if one takes the time to assemble and study the facts. A study of the careers of railroad and railroad supply officers has been made in preparing this report, and it will reveal many essential facts. Additional information can also be obtained from those who are now engaged in railroad and railroad supply work.

It is essential that the young mechanical engineer know his own characteristics and ability. In finding this out, he can obtain considerable assistance from his friends and faculty advisers. The graduate from an engineering school who anticipates a railroad career should carefully consider two questions, namely: Do I want to use my engineering education as a basis for a purely engineering career, or do I want to use it, together with a supplementary business education, as a means of eventually reaching an executive position?

The man who would follow the first course and who is interested in engineering work for the work itself, or in new design and construction, is sure to suffer somewhat of a disappointment in railroad service. Unfortunately, relatively little of the work performed by the average railroad mechanical-engineering office is of a nature that will keep a talented designing engineer continuously occupied with new and interesting problems. The development of the railroad-supply industry has had an important effect in placing the larger part of the design work in the mechanical-engineering department of the manufacturer. In all probability the man following the first course will find greater opportunity in the supply industry.

If the college man entering railroad service is the type who wishes to use his engineering education as a means of possibly reaching an executive position, either in or above the engineering department, then there is one thing that cannot be overlooked—as he advances he gradually becomes more of a business man and less of an engineer. If he has failed to educate himself in the principles of business, the chances for becoming an executive are not great. The railroad executive whose duties may demand an engineering knowledge are such that a relatively small portion of the things which he must know involve a detailed knowledge of engineering principles as compared with the principles of business administration.

The mechanical department of a railroad is but a part of an immense business organization, which like any other business, is operated to make money. Unfortunately, the mechanical department is in a position principally to spend money and save money; as a consequence, the labors of the members of that department are often looked upon as "non-productive." If a college man intends to enter railroad service and be satisfied with what he can learn in any one office or department, he will make no greater progress on the railroad than if he pursued the same tactics in any other industrial organization. The big thing is to know enough about the job ahead to be able to step into it when the opportunity offers and this calls for self education in the principles of business.

Unfortunately, a railroad cannot be run on paper. Operations may be carefully planned beforehand but conditions over which no one has any control may make it necessary to alter these plans at the last moment. Therefore, any college man in railroad service who fails to get as much as possible of the practical side of railroading is doomed to make little progress in the railroad game. Any man who has spent four years in college learning how to think for himself certainly should not be at a loss for ways and means to get all he wants on a railroad.

The Railroad Division's Sub-Committee on Professional Service does not believe that to confer a distinctive title upon a college man in railroad service would materially better his situation. In fact, some consider such titles a considerable handicap. "Titles can be created with the flourish of a pen and wiped out with a bad breakfast." Some of the real jobs on any railroad are those which carry unimposing titles, and on the other hand, some jobs with magnificent titles leave much to be desired on pay-day. Every man who has had practical railroad experience realizes that it is desirable to emphasize his education as little as possible. What the young mechanical engineer should do, in railroad work or elsewhere, is to lose his identity as a college man as quickly as possible.

Two Reasons Why Advancement Is Apt to Be Slow

There are two principal reasons why advancement in railroad work may be slow. First, because the business as a whole is so complicated and departmentalized that it takes years of actual work to become acquainted, even in a general way, with many phases of it. This is in contrast with any line of business that consists mostly of one or two operations, such as buying and selling, or the manufacture and sale of a limited variety of articles, the whole plant being in one place. In any such line, one with reasonable aptitude and liking for the work can much more quickly master the details of it and be in position to advance more rapidly than would be likely in a more complicated and departmentalized business.

The second reason is that the railroads have long since come to a stage of routine as contrasted with immediate and rapid growth. They are organized to handle their business from day to day but are not expanding in any such manner as to call for a steady and large supply of trained men to fill newly created responsible positions. A man who may be very capable is apt to find himself in a situation similar to a bucket in a bucket brigade; that is, he passes along just as fast as those who happen to be ahead of him travel. This is an unavoidable condition in any organization that has attained its growth.

The second reason, however, is subject to a number of modifications. The railroad industry has been going through a number of important developments in recent years with respect to its employees that cannot help but affect an improvement in the status of the mechanical-engineering graduate. Many railroad companies are utilizing the facilities afforded by various state university extension departments, vocational educational bureaus, correspondence schools and other educational organizations for the training of foremen and supervisors. The requirements for the enrollment of regular apprentices are becoming more strict. Some railroads are now requiring a high-school education or the equivalent before a man can enroll as a regular apprentice. Many of the larger railroads are sponsoring such activities as the American Railway Boys' Clubs, the educational features of the Railroad Y. M. C. A., Younger Railroad Men's Conferences, etc., in the effort to raise the standards of supervision. Of course, this means more competition for the college graduate. But it also means more adequate appreciation and utilization of college training by the railroad executives.

Comparison of the Railroad with Other Industries

There are approximately 1000 railroads in the United States and Canada, about 176 of which are Class I railroads (railroads having an operating income above $1,000,000). The Class I railroads operate approximately 90 per cent of the total railway mileage in the United States and earn about 96 per cent of the total revenues. According to the November, 1927, Monthly Labor Review, published by the U. S. Bureau of Labor Statistics, there were employed on these roads in August, 1927, a total of 1,796,194 men and women. A comparison of this figure with the number of employed by other industries during the same period is given in Table 1. The second largest industry according to the number employed is the iron and steel industry, the textile industry being third.

TABLE 1 COMPARISON OF EMPLOYMENT IN 13 GENERAL GROUPS OF INDUSTRIES DURING AUGUST, 1927

	Number of establishments	Average number of wage earners
Railroads	Total Class I*	1,796,194
Iron and steel and their products	1806	648,701
Textiles and their products	1885	602,623
Vehicles for land transportation	1194	479,826
Car building and repairing, steam railroads	559	138,381
Miscellaneous industries	413	251,850
Food and kindred products	1656	223,457
Lumber and its products	1156	219,669
Paper and printing	910	172,365
Leather and its products	360	128,564
Stone, clay, and glass products	638	109,776
Chemicals and allied products	362	88,679
Metal and metal products, other than iron and steel	228	51,595
Tobacco products	173	39,670

* Includes 172 Class I railroads, 15 switching and terminal roads of this class and 24 small roads included in system reports.

Figures showing the proportion of technical graduates —for our purposes, mechanical engineers—to the total number employed would be of value in this table. The Sub-Committee has not, however, found any source from which such information could be obtained. A general idea of the number of supervisory positions in which mechanical-engineering training would be of service is shown in Table 2. Care should be shown, however, in the use of the total figure, due to the fact that many of the executive and staff officers fill positions requiring legal, medical, or business training. Furthermore, this total does not include special apprentices. The division officers and assistants include men in all departments. The larger proportion of the architectural and engineering assistants are in all probability men of civil- or mechanical-engineering training. Special apprentices are usually made inspectors upon completion of their course.

TABLE 2 NUMBER OF EMPLOYEES HOLDING POSITIONS WHERE MECHANICAL ENGINEERING TRAINING WOULD BE OF SERVICE, AUGUST, 1927, ON CLASS I RAILROADS IN THE UNITED STATES*

Executive, general officers and assistants	7,551
Division officers, assistants and staff assistants	9,503
Architectural, chemical and engineering assistants	7,685
Subprofessional engineering and laboratory assistants	4,232
General foremen, M. of E.	1,440
Assistant general foremen and department foremen, M. of E.	11,129
Equipment, shop and electrical inspectors	1,585
Material and supplies inspectors	1,913
Gang foremen and gang leaders, M. of E.	11,036
	56,074

* Wage statistics report, Interstate Commerce Commission, for August, 1927.

A comparison of the total number employed with the total number of officers shows quite clearly that the principal job of the majority of mechanical-department officers pertain more to handling and leading men than to strictly mechanical-engineering work. To illustrate, the superintendent of the car department of one of the smaller Class I railroads in the East has an average of 1200 men under his jurisdiction working at different points on the system. As a further illustration, there are employed by the railroads in the maintenance of equipment about 484,000 men. As a comparison, there are about 1,400 general foremen and 11,000 assistant general foremen and department foremen employed in the Class I railroads in the mechanical department. The general foremen are, therefore, captains of an immense army. Their work may be roughly divided into two parts: first, that of contributing to improvements in shops, shop methods, and shop machinery, and secondly, that of supervising and training employees and improving their morale.

This, in brief, is a summary of the experience and training the college graduate must have to fill higher positions. Finally, the young mechanical engineer must know and appreciate the fact that the railroad industry is subject to regulation by the government. As a rule, government agencies are slow to move and are likely to hinder the development of an industry unless they are able to keep in step with the times. The rules and regulations laid down by the Interstate Commerce Commission affect the work of all departments of a railroad and it is necessary that the railroad officer know just how these regulations relate to the work of his department. The railway-supply-company officer must also be sufficiently familiar with the rules and regulations of the Interstate Commerce Commission to meet its requirements in the materials that his company manufactures. Government regulation, however, has its good features as well as its bad and fortunately the policy of the various bureaus of the Interstate Commerce Commission is one of helpfulness rather than hindrance. In addition, the American Railway Association, of which practically all the railroads are members, makes certain rules and sets up standards with which the mechanical department officers of the railroad and the railway supply company officers must be familiar. Summarizing, training in the utilization of statistics and reports is a necessary qualification to the mechanical engineer in both the railroad and railroad-supply industries.

The Railway Organization

In order to understand the part that the mechanical department plays in a railway organization, a brief outline should be given. The organization of a railway company divides itself naturally into several main departments that have clear lines of demarcation. These departments are the legal, the traffic, the treasury, the accounting and auditing, the operating and the maintenance.

Men of mechanical-engineering education are in demand for service in the maintenance and operating departments. The importance of mechanical-engineering training with respect to the work performed is greatest in the maintenance of equipment department. The work of the traffic department can be compared to that of the sales department of a manufacturing concern and in fact, it actually does sell the services of the railroad to the shipper and traveler.

The operating department mans and moves the trains, operates the yards and mans the stations. It is generally considered to be the most important department. Excluding those who started the railroad career in the executive department as secretary to an executive officer or as chief clerk, it is the operating department that supplies the president on most railroads.

The Mechanical Department

Generally speaking, the mechanical department is usually subordinated to the transportation department. It seems to lack a class consciousness and in this respect is quite different from the engineering department. The mechanical department is in charge of the design of cars and locomotives and of their maintenance in good order. No less than 25 per cent of all railway operating expenses and from one-half to two-thirds of the expenditures for capital improvements come under the jurisdiction of this department. This shows that the job of the mechanical-department officer is one of importance and great responsibilities and requires a man capable of exercising mature judgment.

This statement is undoubtedly emphasized by the figures given in Table 3, which shows the years required for mechanical engineers to reach certain positions in the mechanical department of a railroad. One mechanical engineer worked for 49 years before becoming head of the mechanical department of his road. Another worked for 10 years. The average time required for all those of whom the Sub-Committee obtained complete data was 22.8 years.

TABLE 3 YEARS REQUIRED FOR MECHANICAL ENGINEERS TO REACH CERTAIN POSITIONS IN THE MECHANICAL DEPARTMENT OF A RAILROAD

	Longest time	Shortest time	Average
General supt. of motive power or head of mechanical department	49	10	22.8
Assistant or division supt. of motive power	36	7	18.8
Mechanical engineer	33	4	15.2
Assistant mechanical engineer	11	4	8
Engineer of tests	19	5	9.75
Engineer of motive power	24	7	18

The interests of the railroads and the railway-supply industry are so intimately interwoven that it is impossible to separate them. The railroads are interested in furnishing that standard of transportation which will best meet the public requirements. They are specialists in transportation, and that in itself is no mean task. They are large purchasers of material and supplies, which is indicated by the fact that for several years—since and including 1920—the Class I railroads have expended in excess of a billion dollars a year, chargeable to the operating account for materials and supplies, exclusive of fuel for locomotives.

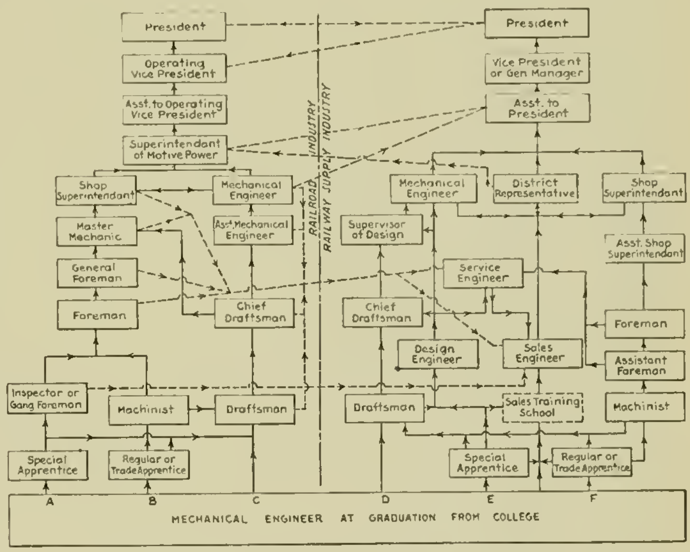


Fig. 1—Chart Showing the General Rates of Promotion Uusually Followed in the Railroad and Railroad Supply Industry

The railway-supply manufacturers, specializing upon the development, production and sale of equipment and supplies and enjoying plenty of competition, have made a remarkable contribution to the railroads and the public served by them. The supply manufacturer must keep in intimate contact with the railway operating problems and practices. He frequently goes to the railroads for men for important places in his organization and relieves the railroad organizations of production details which they are not in a position to handle.

Facts Relative to the Railway-Supply Industry

Over 40 per cent of the executive and technical officers and sales staff of railway-supply concerns, promoted since December, 1919, have either started or worked some time in their careers for a railroad. Approximately

500 manufacturing companies engaged in selling supplies to the railroads. These supply companies employ approximately 7000 men as executives and sales engineers, a large proportion of whom the Sub-Committee has good reason to believe are men of technical education. There are also about 40 private-car companies that own and operate over 1000 cars that should also have need for a limited number of mechanical engineers.

If the mechanical engineer starts at the bottom of the ladder on graduation from college, he can expect to follow one of five general routes for both the railroad and railroad supply industries, inclusive. Referring to Fig. 1, these general routes are lettered consecutively from *A* to *F*. These routes were chartered from replies to questionnaires sent to a selected list of railroad and railroad-supply companies, and from an analysis of the careers of various railroad and railroad-supply officers. The dotted lines show some of the transfers that have actually been made by men between the two allied industries. In this connection, it is well to keep in mind that the men who have transferred from railroad to railroad-supply companies, and vice versa, have been able to do so on the experience or record attained in either one of the two industries. In other words, the essential experience and requirements for both the railroad and railroad-supply industries are, from all practical standpoints, basically the same.

The Sub-Committee on Professional Service does not wish to convey the impression that each man must necessarily follow one of the five general routes shown in Fig. 1 to get to the top. Analysis of the careers of railroad and railroad-supply officers shows that some have jumped from one route to another or skipped one or more positions in the usual direct line of promotion. There have been instances where special apprentices have become machinists and there have also been instances of promotion to foremen on the completion of the special apprentice course. It depends on the characteristics and ability of the individual whether he moves slowly or rapidly to higher positions of responsibility.

Analysis of the careers of officers in both the railroad and railway supply industries show that the college graduate has a distinct advantage over the non-college man. Table 4 shows the results of a study made of the railroad careers of 25 railroad officers in six different grades. The right-hand column of the table shows the number of years gained by the college graduate in reaching each position listed over the time required by the non-college man in reaching the same position. The officers, selected at random, are all employed by Class I railroads.

TABLE 4 AVERAGE AGES OF 25 RAILROAD OFFICERS IN EACH GRADE SHOWN, TIME REQUIRED TO REACH CERTAIN POSITIONS AND TIME GAINED BY COLLEGE GRADUATES

	Average age, years	Average time in R.R. service, years	College trained, per cent	Average time for non-college man, years	Average time for college graduate, years	Time gained by college graduate, years
President	58.3	30	53	34	24	10
Vice-President	50.8	28.1	48	30.7	25.2	5.5
General manager	49	30.5	16.8	31.4	26.2	5.2
Superintendent of motive power	43.8	25.8	44	29.9	19.9	10
Mechanical engineer	35	13.75	80	14.6	13.5	1.1
Master mechanic	47.4	22.7	20	24.1	15.2	9.4

In studying this table it is well to keep in mind the fact that the superintendent of motive power is the active head of the mechanical department. A master mechanic is head of the repair shops of a division and quite often has charge of both locomotive and car repairs. On most roads, however, the master mechanic has only locomotive maintenance to supervise. The mechanical engineer usually reports to the superintendent of motive power, and his work generally pertains to the design, alteration and selection of rolling stock and shop equipment. Practically all of the mechanical engineers in Table 4 are college graduates. Those who are not college graduates obtained their technical training at night school or by home study. This accounts for the small gain of 1.1 year by the college man over the non-college man. In other words, practically all of the mechanical engineers employed by the railroads have had a college education or its equivalent.

The Sub-Committee felt it to be essential to have all the information contained in this report of as recent date as possible. Table 5 shows the careers of officers holding certain representative positions in railway-supply-manufacturing companies. In collecting data for this table, only the careers of officers promoted since December, 1919, were considered.

TABLE 5 CAREERS OF OFFICERS HOLDING CERTAIN REPRESENTATIVE POSITIONS IN RAILWAY SUPPLY COMPANIES

	No.	No. who started on R.R.	No. who started with R.S. Co.	Education: Common school	Education: High school or equiv.	Education: College grads.	Per cent of college grads.
President	28	6	22	4	6	18	55
Vice-President	37	22	15	10	8	19	51.4
General manager	13	4	9	2	1	10	77
Chief engineer	11	4	7	1	1	9	81.8
Manager of sales	12	7	5	2	3	7	58.3
Railroad representative	12	9	3	2	1	9	75

TABLE 6 AVERAGE AGES, TIME REQUIRED TO REACH CERTAIN POSITIONS, AND TIME GAINED BY COLLEGE GRADUATES —RAILWAY SUPPLY COMPANIES

	Average age, years	Average time in R.R. & R. S. service, years	Average time for non-college man, years	Average time for college graduate, years	Time gained by college graduate, years
President	56.6	27.1	35.5	22	13.5
Vice-President	47.75	28.9	32.2	23.8	8.4
General manager	44.7	29.2	32.4	26	6.4
Chief engineer	46.25	23.2	31	20	11
Manager of sales	46	21.75	27.25	18.9	8.35
Railroad representative	43	27.1	20.9	3.8	17.1

Table 7 is arranged for comparison with Table 4. Higher officers are included in Table 7, however, owing to the fact that the duties and responsibilities of many railway supply company executives involve problems that are of a mechanical-engineering nature.

It can be said that a large share of the problems confronting the president of the average railway supply company are similar to those of the superintendent of motive power of a Class I railroad. He should have sufficient technical knowledge to make intelligent decisions on engineering problems.

TABLE 7 YEARS REQUIRED FOR MECHANICAL ENGINEERS TO REACH CERTAIN REPRESENTATIVE POSITIONS IN A RAILWAY SUPPLY COMPANY

	Longest time	[illegible]	Average
President	45	[illegible]	26.8
Vice-President	39	[illegible]	25.2
General manager	45	[illegible]	29
Chief engineer	36	[illegible]	26.4
Assistant engineer	22	[illegible]	9
Manager of sales	40	[illegible]	[illegible]1.2
Assistant or district manager of sales	26	[illegible]	[illegible]
Railroad representative	43	[illegible]	[illegible]

Salaries Paid in the Two Industries

One of the questions asked in the questionna[illegible] to the various railroad and railway supply com[illegible] 1927 was: What length of time is required fo[illegible] to reach a position paying, say, $5000 a year? [illegible]marizing the replies, some railroads do not p[illegible] amount. On those railroads that do pay this sum, the time required would be not less than ten years in th[illegible] ordinary course of advancement. Again summarizing the replies of the railway supply companies: no definite length of time can be determined; it will vary with conditions and individuals.

A tabulated analysis of the earnings of engineering graduates in all industries is also shown in Table 8. The data shown in this table were supplied to the Society for the Promotion of Engineering Education by cooperative committees from the faculties of a large number of technical institutions in connection with an investigation made by that Society in 1924. The information was obtained by the faculty committees from their respective alumni.

TABLE 8 ANALYSIS OF EARNINGS OF ENGINEERING GRADUATES IN ALL INDUSTRIES AS OF JUNE 1, 1924*

			Annual Earnings, in Dollars					
Class	Years since graduation	Number reporting	Limit of lowest 25 per cent	Median	Limit of highest 25 per cent	Maximum	Most frequent
1924	0	1,191	1,200	1,476	1,560	4,080	1,200
1923	1	1,218	1,560	1,800	1,980	5,100	1,800
1922	2	1,023	1,800	2,100	2,400	9,000	1,800
1919	5	309	2,400	2,860	3,500	25,000	3,000
1914	10	498	3,110	4,000	5,100	50,000	5,000
1909	15	430	3,600	5,000	8,000	49,500	6,000
1904	20	238	4,000	5,500	10,000	90,000	4,000
1894	30	116	4,500	7,500	15,000	100,000	6,000
	Total	5,023					

* Study of Engineering Graduates, published by the Society for the Promotion of Engineering Education, p. 287.

TABLE 9 MAXIMUM, MINIMUM, AND AVERAGE ANNUAL SALARIES PAID FOR CERTAIN REPRESENTATIVE POSITIONS OR THEIR EQUIVALENTS IN THE MECHANICAL DEPARTMENT OF A RAILROAD IN 1921

	Maximum	Minimum	Average
General superintendent of motive power or head of mechanical department	$25,000	$4,500	$8,430
Assistant or division superintendent of motive power	10,200	4,000	6,660
Mechanical engineer	11,320	4,000	5,410
Assistant mechanical engineer	9,600	3,700	4,930
Engineer of tests	10,000	4,000	5,680
Engineer of motive power	8,000	4,000	5,940

Table 9 shows the maximum, minimum and average salaries paid for six representative positions in the mechanical department of a railroad.

Conclusion

It is the belief of the Railroad Division's Sub-Committee on Professional Service that if the young mechanical engineer or mechanical engineering student is convinced that he will like railroad or railroad-supply work and has a special aptitude for such work he will succeed in getting ahead in either of the two allied industries. The degree of success depends largely on the characteristics and ability of the individual. This, of course, holds true for all industries as well as the railroad and railroad-supply industries. On the other hand, it is the consensus of opinion that both the railroads and the railway supply companies need the young technical graduate, and this report would indicate that in salary and opportunity he can hope to achieve the same degree of success as in other engineering and industrial lines. Finally, the Sub-Committee wishes to stress the value of personal investigation to ascertain the facts pertaining to the opportunities afforded in any industry he is considering entering before arriving at any final decision or committing himself to a definite line of work.

It is the opinion of the Sub-Committee that the salary situation as shown by the wide area between the maximum and minimum figures is a fairly accurate picture of the earnings of the mechanical engineer in industry.

Increased Investment in Road and Equipment

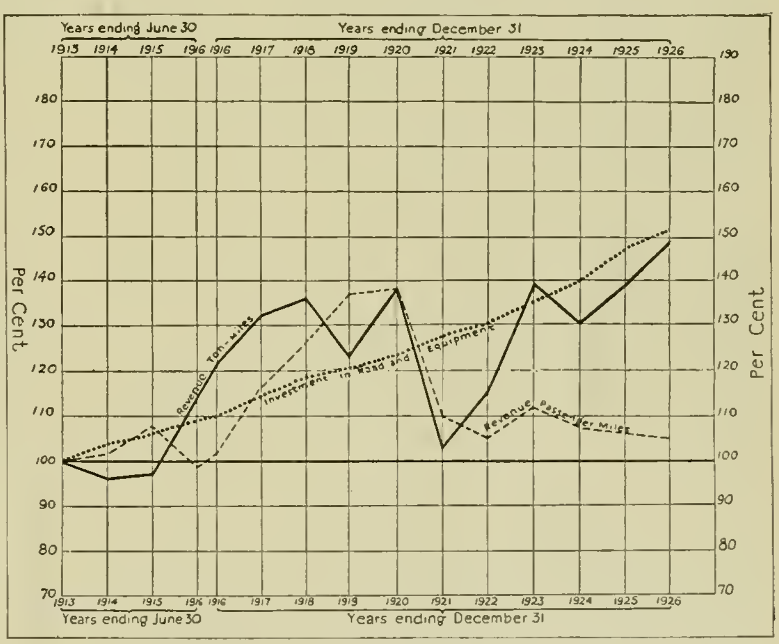
That the growth of railway facilities has more than kept pace with the traffic demands made upon the steam carriers is shown by the fact that the percentage of increase in investment in road and equipment has been greater than that of ton-miles. This conclusion is borne out by a study of the records of the Class I railroads since 1913.

In recent years the railroads have been spending approximately 750 million dollars annually for additions and improvements to their physical plant. As a result of these capital expenditures the railroads have effected substantial improvements in their efficiency of operation.

A feature of the capital expenditure programs has been a gradual change during the last few years whereby a progressively smaller proportion of the total has been directed to equipment, and a correspondingly larger proportion to fixed property. Such property includes yards and terminals, grade revisions, stronger bridges, signals and interlockings, grade crossing eliminations, and other improvements of a similar character.

Freight traffic as measured in ton-miles, handled by the Class I railroads in the peak year for all time, namely 1926, showed an increase of 49 per cent as compared with 1913—taken as the base year—according to data furnished by the Bureau of Railway Economics. The peak year for revenue passenger-miles was reached in 1920, with the percentage of increase over 1913 amounting to 38 per cent.

Investment in road and equipment, on the other hand, has shown a steady upward trend since 1913, with the result that in 1926 such investment was 52 per cent greater. It will be seen in the accompanying chart that investment in road and equipment runs below the ton-mile curve from the years 1916 to 1920 and also in the heavy traffic year of 1923. In 1925 and 1926, however, both years of heavy freight traffic, the relative increase of the investments in road and equipment was large enough to



Comparison of the Growth of Railway Traffic with Increase in Investment in Road and Equipment, Presented in Percentage of 1913 as 100

exceed the proportionate increase in the freight traffic.

In other words, the large capital expenditures of the past four or five years have made possible fast and dependable railway service; and the increasing economy of operation in recent years has been the result of the railways' willingness to spend money to save money, thus increasing the capacity of the transportation plant.

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Economy in Fuel

One of the most important, if not the most important subject pertaining to locomotive operation that effects operating economy, is the economical use of fuel. This is a subject that never wears out and well may it be kept on the calendar as it were, for reference, discussion or comment whenever the subject of operating economy is touched upon.

It has been a policy of Railway and Locomotive Engineering to not only keep this question constantly before our readers, but to aid in a constructive way all those who were disposed to make progress in the most fertile field for improved locomotive efficiency.

In keeping with the above mentioned policy, we have not only offered suggestions pertaining to questions of locomotive design, but have presented at different periods, particularly during the past five years, much statistical data, conveniently tabulated for comparative purposes. In this form these tables have served the double purpose of giving credit to those who have already made remarkable strides in the economical use of locomotive fuel, but also served to point the way and urge those with less complimentary records to put forth their full energies in that direction.

We again call attention to the article elsewhere in these pages under the title "The Past and Future in Railway Efficiency," and particularly to the tabulation on page 64, in which some of the more important items pertinent to operating economy are shown for forty of our leading trunk lines. The tabulation will serve as a good "yard stick" or measure of comparison for those who are striving for better records.

It must be borne in mind however, that these statistical records should be used with such degree of caution as will prevent unfair comparisons due to local conditions, that may be responsible for results that might otherwise be erroneously charged against operating efficiency.

There are many items in the table which if studied in comparison with the results obtained by other lines in the same or similar territory and with past records, will serve to emphasize what has been accomplished and clearly indicate what can yet be done in this most important matter. As an illustration let us take the items of:

(a) Pounds of coal consumed per 1,000 gross ton miles.
(b) Pounds of coal per passenger car mile.
(c) Average locomotive miles per day.
(d) Average revenue tons per freight train.
(e) Average miles per freight car per day.
(f) Average speed of freight trains per hour.
(g) Average cost of coal per ton.

While these items may not all be listed in the order of their importance, yet the first item seems to be the principal one in freight train operation.

On reference to the tabulation it will be noted that the pounds of coal per 1,000 ton miles vary from 90 lbs. to 195 lbs., while the average of the 40 trunk lines is 123 lbs. It is clear that there is room for much improvement on some of the roads with the poorest records. At the same time some of those showing a low figure for this item may, and no doubt can, materially improve their records.

It would be manifestly unfair to certain lines however, if we failed to point out to those who may not be conversant with local conditions, that some of the lines with apparently the poorest records may be as efficiently operated as others with much better appearing figures.

This is particularly true with respect to lines almost wholly in a mountainous country with heavy grades, or in the more densely populated district where a large percentage of the freight service is for short distances, and where frequent stops and much switching work is done by road engines.

Among the more conspicious examples, we may use the following lines to emphasize that phase of the matter.

The Pittsburgh & Lake Erie which shows a coal consumption of only 90 lbs. per 1,000 ton miles is what is known as a water level line between Pittsburgh, Pa., and Youngstown, Ohio, with an average of 1,500 tons per freight train, while the Denver & Rio Grande is entirely located in the Rocky Mountains with heavy grades to negotiate. Consequently, the average tonnage per train of 709 tons and the fuel consumption of 195 lbs. per 1,000 ton miles on the Denver & Rio Grande may represent as high a degree of operating efficiency as the results shown by other lines located in the valley or level country with comparative freedom from adverse gradients.

In the item of pounds of coal per passenger car mile, which varies from 11.7 lbs. to as high as 28 lbs., or a difference of 16.3 lbs., it must again be remembered that the line consuming only 11.7 lbs. is almost a perfectly level road, with a preponderance of through line passenger trains with an average of more than 9 cars per train. The line that consumed 28 lbs., does a heavy suburban business with short trains and frequent stops. The stand-by or terminal losses in suburban service is also a big item that adversely effects the fuel record.

Great strides have been made in fuel economy and operating efficiency in the matter of increased mileage of both freight and passenger engines and while the results shown in the tables are both instructive and interesting, their value will be more fully appreciated by a comparison with records of former years.

The range of average mileage of freight engines from 61 to 128 miles per day, and from 88 to as high as 247 per day in passenger service when compared with former years, not only shows what has been accomplished but also suggests further improvement on certain roads.

In freight service, the average miles per engine per day also bears a close relation to the average speed in miles per hour of freight trains, which it will be observed ranges from a 7.8 on a heavy coal carrying road that does only 8.5 per cent passenger business to as high as 14.2 miles per hour on a trunk line with 32.5 per cent of passenger revenue.

The average miles per freight car per day effects fuel economy only in an indirect way but the improvement in this item shows that great strides have been made in increased efficiency of the transportation unit as a whole.

Here again however, one must first compare the results with those of a few years ago when the average for the United States was about 24 miles per day. In this connection local conditions and the character of the service must be understood and allowance made in comparing an average range of from 17 miles to as high as 61.5. The line making 61.5 miles is strictly a transportation road hauling solid, through, long unbroken trains. It is in a sparsely settled country with relatively little switching to do, while the line with only 17 miles per day is a heavy receiving and gathering line, in the congested eastern territory with almost a continuous switching service from one end to the other.

It is worthy of note that in 1922 the Pittsburgh & Lake Erie only made an average of 7.4 miles per freight car per day and the New Haven only 11.9. The records now show the former increased to 11.9 or about 60 per cent while the latter increased from 11.9 to 17 miles per day, or more than 50 per cent.

In the matter of reduction in total cost of locomotive fuel, it must be remembered that, as pointed out in the December issue of this paper, that the cost per ton dropped from $3.22 in 1920 to $2.21 in 1926. This accounts, of course, for much of the drop in the total fuel bill from $689,632,093 to $418,503,588.

The field however is broad and inviting and if the matter is properly handled will yield wonderful returns on time, labor and funds expended.

Railway Maintenance Facilities

In a consideration of railway maintenance facilities we can without any impropriety make the following Biblical quotation "Muzzle not the ox that treadeth out the corn," which, interpreted and applied to present day railway transportation means that:

(a) From earnings or capital account, adequate facilities must be provided to properly maintain the physical plant;

(b) That the aforementioned expense should come first thus taking precedence over *all* others.

It is gratifying to note that appropriations and expenditures for additions and betterments during the past five years were as follows:

1923	$1,059,149,000
1924	874,743,000
1925	748,191,000
1926	885,086,000
1927	771,552,000
Total	$4,338,721,000

The budget for 1927 carries over the following amount into the year of 1928: $335,254,000.

It may be of interest to note that of the entire budget for 1927, that $35,236,000 or about 4.5% was for shops, engine houses and machinery, which would indicate a continuance of not only a fairly liberal policy in general, but, with respect to facilities for the maintenance of equipment it might well be increased, as this item of expense has in the past, with certain exceptions, been shamefully neglected.

For many years, particularly during the era of greatest activity in railway building in this country, the slogan was "mileage, earnings and dividends," to which everything else was subordinated. Steam locomotives were too often treated as range cattle, i. e., as mediums of wealth to their owners. The electric locomotives would have received no better consideration were it not for the fact, that, owing to their more complicated and delicate characteristics, it was simply impossible to accord them the same degree of *neglect* or *abuse* as was meted out to the steam locomotives, and have them function at all. It was simply impossible.

Nothwithstanding the above conditions, inadequate facilities for the maintenance of equipment was most pronounced, and improvement slow.

There were of course, some striking exceptions to the general conditions in which some managements recognized the full import and meaning of the Biblical injunction, which was well reflected in the proper upkeep of the physical plant, and safeguarding the integrity of the company's capital account.

There were numerous instances however of roads paying dividends, earned by steam locomotives, which after facing the elements over the line while in service, stood outdoors in zero weather in snow and sleet, and then were expected to render good service. Any one of experience knows that to be an impossibility.

With the numerous additions of accessories to our steam locomotives in recent years, and the more delicate characteristics of the electric locomotive or tractor, ample housing and repair facilities are not only essential to good management, but with respect to the latter unit it is an absolute necessity. In fact it is a pre-requisite to an economic going concern.

Proper supervision, inspection and actual repairs can only be expected in a well appointed, properly heated and ventilated, clean, tidy roundhouse or shop.

Most railway managements have in recent years not only recognized, but made provisions for adequate facilities for proper maintenance of equipment, particularly prime-movers affected by the various climatic and operating conditions. If, perchance, there may be some who have failed to fully recognize and act favorably on this fundamental feature, we beg to intrude the suggestion that other fields of activity should be more appropriate and inviting for them.

Progressive in Spots

In the record of most human activities, particularly in the arts, science and engineering, will be found on close examination a lack uniformity. This is especially true in the field of steam engineering where great strides have been made, notwithstanding the fact that certain branches have often been highly developed, while other, and not infrequently more important features, have lain dormant through inattention or neglect. We have several times not only touched upon this subject in a general way, but have pointed out the specific places to which this criticism applied and indicating where a normal and often a trivial expenditure would bring great financial returns.

In the development of the steam locomotive, engineers and inventors seem to have run true to form; that is in cycles. Sometimes they actually wasted much time and energy and great sums of money on a feature or part that offered little in return, while, some other detail still in a semi-crude state of development was crying as it were for relief but remained almost unnoticed. For many years the boiler of our steam locomotive received comparatively little attention, while great sums were being expended on the machinery through the medium of which useful work is accomplished. The conventional boiler is limited to about 250 lbs. of steam and is uneconomical in steam production and expensive to maintain.

Just why we have adhered so strongly to the present boiler design when there is such an excellent opportunity to improve upon it is hard to answer. Therefore, any person who can submit a correct answer to the question can explain why we are at times progressive in spots.

In our last issue we made reference to the trend toward higher steam pressures and suggested that they be considered in reference to other fields, aside from the steam locomotive.

In this issue we are able to give another example of the progress made in Switzerland with a 3-cylinder locomotive using steam of 850 lbs. pressure, the conventional method of mechanism being departed from by the employment of a jack-shaft without the usual gearing.

The locomotive referred to not only embodies distinct features in both the boiler and engine, but particularly emphasizes the decided trend toward the boiler or steam producing part of the complete unit as a most promising direction in which genius may well be directed.

High Pressure Locomotives

In connection with our editorial in last month's issue on the subject of high pressure locomotives, we are able to present some details of the service of a high pressure steam locomotive, built in the latter part of last year by the Swiss Locomotive and Machine Company of Winterthur, and which was subjected to road tests during the month of January, 1928.

The engine is a three-cylinder simple high-speed locomotive operating with a boiler pressure of 850 lbs., the drivers being operated through a non-geared jack shaft. The engine is the result of several years of research work, preparatory trials, and stationary tests. The actual road tests were made in comparison with a conventional superheated steam locomotive with 170 lbs., steam pressure and of equal output in order to ascertain the saving in coal and water.

The tests were conducted under the control of the Swiss Federal Railways and showed remarkable savings in favor of the high pressure engine as the following details will attest.

Test Section of Line	Winterthur Romanshorn and Return		Winterthur Stein/ Sackingen and Return		Percent Increase for High-pressure Engine
Length in miles...	70		93		
Maximum gradient	1 in 83⅓		1 in 125		
Weight of train behind draw-bar, tons	242		300		
Class of engine	High press.	Low press.	High press.	Low press.	
Average speed in miles per hour..	38.4	37.7	34.2	33.2	Plus
Coal consumption in pounds......	1710	2600	2230	3200	35 to 40
Water consumption, Imperial gallons	1150	2100	1440	2690	47 to 55

Measured by economy in fuel and water, this new high-pressure locomotive shows results over the ordinary type of engine with 170 lbs. boiler pressure to warrant the prediction that higher steam pressure will be gradually introduced into railway practice, thus confirming the prophecy of those who have consistently and persistently urged its adoption by steam users in general, and railways in particular.

Japanese Railways

Our British contemporary, "Modern Transport," has published three special issues devoted to the railroad system in Japan. These issues are dated March 17, 24, and 31 and may be obtained from the publisher, Norman House, 105-109 Strand, London, W. C. 2, England, price 15 cents per copy including postage. They are published with the full cognizance of the Japanese railroad administration, and our London correspondent suggests that they are worth the careful attention of anyone who is interested in the Oriental market for locomotives, rolling stock and railroad appliances.

Locomotive Design

By Arthur Curran

The other day, I was looking over some of the railway data, which represent the patient labor of many years, when I came across particulars of a locomotive which "set me to thinking." The engine, a very handsome example of the Pacific type, was built about fifteen years ago for a western road. In most respects, it exemplified the best characteristics of modern motive power practice; and yet, somehow, its actual power output was not remarkable, even for its day.

One very obvious reason for this was the fact that, at a time when a boiler pressure of 200 lbs. was very common, this engine carried only 180. Another detail which struck me as odd was the very moderate grate area of 51 square feet, when contemporaneous engines of the same type and similar weight had between 55 and 60 square feet of grate.

Had the designer "kept in step" with the trend of the times, his engine would have been a wonder; as, in other respects, it was a remarkably fine job. If he had looked ahead a little and used 220 lbs. of steam, this engine would have been the smartest and, probably, most powerful of its type and size in the world!

It is not advisable to disclose further details, as such a course would "give away" too much! Enough has been adduced, however, to provide food "for thought." The fact—long suspected!—that the possibilities of this type were not fully developed on some roads is pretty well established by now. That much more could have been done than was done must be clear to any competent observer of motive power practice.

Of course, "much water has passed under the bridge" in fifteen years. The Pacific type has "come into its own" on many of the best railroads in the country, and some very fine results have been achieved in the field of combining great starting power with the capacity for sustained high speed.

The point is, however, that, so long as fifteen years ago, at least one designer came very near to producing a world-beater within limitations of weight which, in these days, would be regarded as excessively conservative.

I realize that, unless the details had been worked out very carefully, such an engine would have been slightly "slippery." Even so, she would have been tremendously smart and sweet-running at speeds above 50 m. p. h.

As traffic between great commercial centers increases and frequency of service becomes imperative, some solution of the problem will have to be arrived at. The sort of designing that goes very well for exceptionally heavy trains, will not do under these conditions.

At the present time, there are in service on American railroads of the better class a number of well-designed and useful locomotives of the Pacific, Mikado and other types which have been superseded on the best runs by larger engines of the same or other types. If not well maintained, they will very rapidly depreciate in value and thus become candidates for the scrap-heap. On the other hand, if they can be "carried" a little while longer, a re-adjustment of traffic may restore, in some measure at least, their original usefulness.

Careful study of a good railroad map, in the light of some knowledge of probable trends of development, will prove very illuminating; especially as regards territory that has not yet been "worked out."

Hence, some thought should be given to motive power having three or more pairs of drivers, wide fireboxes over trailers, and modern cylinders and valves, before they are condemned for scrap. Very naturally, the age and general condition of boilers and fireboxes will determine the nature of the decision regarding such engines. In quiet periods, however, it might be a good plan to keep shop forces busy by re-conditioning the more promising of the older engines.

Some rather surprising results have been achieved in this manner; the more welcome in view of the enforced retirement of obsolete and absolutely useless types of power. The man who sits at a desk in New York or Chicago has no idea of the number of sad, old wrecks which still limp around on some of the biggest roads in the country! They will have to go some day—and that day is not far off! If the supply men rejoice when that happy time arrives, I, for one, shall not discourage their merriment. Certainly, the practice of having an unusually fine group of engines for pet trains, and nothing back of them but a heterogeneous assortment of scrap, is not exactly good business.

The more advanced examples of designing—to which brief reference was made earlier in this article—call for special handling. In other words, enginemen, who have been accustomed to running certain classes of power, need instruction when they are assigned to some of these new locomotives. Failure to insist upon the right handling of such power results in loss of efficiency and general dissatisfaction. This point is well understood in England, where inspectors—corresponding, presumably, to our road foremen of engines—ride on locomotives and check their performance. And, believe me, this checking is no perfunctory farce! It is thorough in the extreme, and gets results. If an engine is at fault, a remedy is applied; and if a crew makes mistakes, the proper methods are expounded for their benefit.

Most of us have had to give up many of our cherished opinions since the modern era of motive power design set in about twenty years ago. Some of us may recall designs which just missed being great. And that suggests the celebrated case of the dress-maker who had considerable talent, but failed to get her shop on Fifth Avenue because she, too, "just missed being smart and chic."

So, in conclusion, it may be said, for the thousandth time, that designing locomotives is a fine art. If, dear reader, you do not believe this, you may begin your education by taking a job with a firm which supplies choo-choos to exacting customers. If you last, you will be convinced!

British Railway Notes

By R. W. A. Salter

Longest Non-Stop Run

The London and Northeastern Railway of England are about to institute a non-stop run from London to Edinburgh, a distance of 395 miles. The record is at present held by the London, Midland and Scottish Railway, who operate a train between London and Carlisle, 209 miles, without stop. For many years the distinction of providing the longest non-stop journey belonged to the Great Western Railway, whose "Cornish Riviera Express" does the trip from London to Plymouth (226 miles) in four hours. Recently the Southern Pacific Company claimed the world's non-stop record for their "Daylight" train, operating between San Francisco and Los Angeles, 471 miles. It should be borne in mind however that this is not, strictly speaking, a non-stop run, as the train makes two halts for fuel and water.

Automatic Train Control

The announcement that the Chicago and Northwestern Railway intend to install automatic train control on their line from Chicago to Omaha has received a considerable amount of attention in the British newspapers. Automatic control has not yet been widely adopted in Great Britain, and a Government committee was appointed early in January to review the situation. A combined automatic control and audible signal system is in use on the Great Western Railway, but applies only to about 200 miles of their track. The apparatus consists of a ramp, about 40 ft. long, fixed between the running rails, made up of a steel T bar mounted on a balk of timber. It is slightly hump-shaped, and at its highest point is about 4 in. above rail level. In the centre line of the locomotive is a contact shoe projecting to within 2½ in. of the rail level. This shoe is raised 1½ in. in passing over each ramp. The lift opens a switch connected with the electrically controlled brake of the locomotive. The ramp is connected by wire with a switch in the signal box, and when the lever of the distant signal is placed in the proceed position an electric battery is connected to the ramp. The ramp is therefore electrified and the effect when the contact shoe passes over it is to ring a bell in the cab of the locomotive informing the driver that the distant signal is at proceed. Should the signal be at stop, or should the wire break or the electric battery fail, the ramp is electrically dead, and when the contact shoe passes over it it causes the admission of air through the electrically controlled brake valve and siren, automatically operating the brakes throughout the train, while at the same time giving a warning to the driver that the distant signal is at danger. In British railroad circles this system is considered far more likely to ensure safe operation than that adapted by the Chicago and Northwestern Railway, which is worked by an electric current along the rails picked up by coils on the front of the locomotive.

Third-Class Sleepers

After an agitation lasting over many years, the British railroad companies have decided to introduce third class sleeping cars. Designs and estimates have been prepared, and it is the intention of the companies to adapt a number of their third-class vestibule coaches experimentally and to put these into use in a few months. The cars will provide lying-down accommodation at a moderate charge, but it is not proposed to supply bedding.

Obtaining a Higher Standard of Equipment Maintenance*

By E. J. BURCK, Superintendent of Shops, Michigan Central Railroad

Locomotive maintenance is a most interesting and fascinating study. The problem of how to obtain a higher standard of equipment maintenance is one that concerns everyone, and becomes more important each year. With the progress made in locomotive design, it is necessary for us to become students and study these new applications.

The maintenance of a locomotive begins the day it is received from the builder, first in engine house and later in shops. Motive power must be maintained at a high standard and it must be efficiently operated at the same high standard. The engine terminal is the pulse of the motive power department; if you have a sick engine terminal, you certainly get motive power incapable of making successful trips.

The modern locomotives are equipped with special appliances, which are operated by air, steam or electricity, to increase their hauling capacity; all these add materially to the maintenance of locomotives. For instance, the superheater conserves fuel and water. The booster is added to accelerate a train in starting or to boost it over a grade or out of a hard spot. Stokers are added on account of the human element being unable to handle the pounds of coal per hour continuously and maintain the required steam pressure to handle successfully present tonnage trains.

In reality, the maintenance of a locomotive begins on its arrival at cinder pit after completing its run. At this point the engineer gives the locomotive a thorough inspection and I contend that a mechanic should meet the locomotive, as it is delivered to pit, and there make a joint inspection with the engineer. If a bad pound has developed, this can be easily traced by both engineer and inspector, they making a joint inspection. The same policy holds good in regard to locomotive blowing. Outside inspection during daylight hours gives very good results and in particular if done before fires are knocked out. Fractures are more readily distinguished on both rods and motion work, also condition of tender and parts above running board, and boiler mountings in the cab can be more readily inspected and defects more easily found.

Modern terminals are equipped with wet ash pits, which have the advantage over the old type of pit with depressed tracks. The wet pit avoids congestion of locomotives going over them, and allows terminal force more time for attention to locomotives.

After fires are knocked out, many plants have an engine washing system where engines are thoroughly washed, which give them a very neat appearance. Clean locomotives offer several advantages other than that of giving an attractive appearance. True as it may be, the fact still remains that clean locomotives are a material aid in maintenance work, and defects, not found by outside inspectors, are more discernible and can be located with minimum amount of inspection when a locomotive is clean.

Many roads have different methods of handling their work reports from both engineers and inspectors. One form quite commonly used is the book form, in which reports are written by a clerk who copies the work reported on work slips, printing one item on each slip. These slips are then handed to the man assigned to do the work. After the work has been completed the work slips are signed and returned, checked against the book and filed. Another form is the single blank on which all reports are recorded and blank is placed under glass on post next to engine, from which men work and sign up for their own class of work recorded on this sheet. We formerly used the book form and distributed the work by use of work slips. Just recently we have adopted the latter method and find that better results are obtained; foremen can follow the work better and men are more alert in doing the work assigned to them. In order to protect ourselves in case the original sheet is destroyed, a copy of same is made at the time engineer makes his report and this copy is kept until original is returned and both are filed away.

On our late power we have many new devices which need daily attention, such as stokers, power reverse gear, feed water pumps and heaters, boosters, etc. I find, that where one mechanic and helper or apprentice is assigned to this work on each trick, it can be taken care of very nicely, his duties being to test out these devices when engine is hot and maintain them. By working men under this system they will make many suggestions in order to do their work more efficiently, provide themselves with certain tools, and study this class of work. I believe in giving this man an apprentice as a helper, as an alert apprentice will analyze and study details entering into the design and construction of these modern parts.

Engine house problems involve many features; there are problems to be met that are peculiar to the individual railroad. These of course are governed by the policies in vogue on that particular road, and conditions existing in one locality will not answer the same purpose in another.

On account of the heavy work done in our engine house, we have started a schedule system and find we are getting good results by this method, as we all know what work engines are held for and the date work is expected to be completed. On this same schedule, which is made out daily, we also show locomotives which are to be held for certain kind of work, after those then tied up are finished.

The following is a sample of engine house schedule report:

Date ....

.... Div. M. M., ... Supt. of Shops, ... Eng. House Foreman, ... Assist. Eng. House Foreman, ... Boiler Foreman, ... Drop Pit Foreman, Painter Foreman, etc.

Eng. No. New. Turn over today.
Eng. No. Put up ecc. and straps, set valves today.
Eng. No. Put up No. 1 and 2 wheels, rods and motion work, to be finished .... (date).
Eng. No. When held apply new sealing rings to stoker.
Eng. No. Stop for shop Sept. 6th.
Eng. No. Change tires and apply new trailers, give all rods and motion work an overhauling.
Eng. No. On return stop for tire change.
Eng. No. When consistent hold engine to take up lateral to renew rod brasses, overhaul motion work.
Eng. No. Hold for change of trailer wheels and turn over today.
Eng. No. Give boiler part set of flues and cap removal, give machinery monthly inspection.

* *A report presented to the International Railway General Foremen's Association.*

Eng. No. Apply dead engine feature, test air and send engine to Detroit under steam in train.
Eng. No. Take up with dispatcher and get engines back to this terminal.
Eng. No. Get out of storage and have ready for service .... (date).
Eng. No. Apply injectors equipped with 4,000-gal. tubes and send on JB 1, road foreman to ride engine.
Eng. No. Put in storage on return.
Eng. No. New, O.K. 50%.

This really is not a schedule, but a reminder.

Some of you will not agree with me that heavy work should be done on engine 1-A. Conditions that exist on your road does not compare with ours. We do not believe in filling up our shops with engines due for light work; our shops are used for engines given classified repairs. Some of you are given credit for classified repair by giving engine light repairs. Not so on the road I am connected with. We get credit only when mileage can be dropped.

The man holding the title of drop pit foreman handles the work in engine house. Regular engine house men do not come under his supervision. These drop pit men work regular shop hours. The assistant engine house foreman handles all the work on running engines. But we do expect the engine house foreman to supervise them, or have charge of gang doing heavy work.

Heavy machining work to engine repaired in engine house is handled by shop forces. Information of work to be done is conveyed to shop foreman at schedule meeting which is held twice a day. This work does not cut into shop schedules much as it is pretty well distributed throughout the shop.

The maintenance of a locomotive must be studied, and if a failure occurs analyze the cause of the failure. In a great many cases it is the design of certain parts and it is up to the supervision to recommend a change, if necessary, so that failures will not occur. Here at this convention is where you can get in touch with men representing the different parts of locomotives and put your troubles up to them. We must say that we have gained some excellent information from studying the exhibits in the other room, while attending these conventions during previous years, and we will do it again this year. If something looks good to you, make your recommendations, it will bear results.

Present traffic conditions demand that engines stand up to their requirements. Locomotives of today are required to handle heavier and make longer hauls. The standards entering into the anatomy of the locomotive must be so designed that it will give this service. We must not think that it is only the machinery that needs the attention, but remember that the boiler must be given equal maintenance and must not be neglected. A little inspection by a supervisor after the boiler work is okeyed will give wonderful results. Flues sometimes are not properly cleaned and, with some of the styles of superheat units which we have, it is absolutely necessary that we have clean flues. Be an inspector yourself and see what you can find that is not properly done. After you have noticed the boiler work checked off, send an inspector into fire box and have him report to you the conditions found; if work is not properly done, discipline to the employee who is responsible for this class of work will bear wonderful results, it will affect the men on other shifts.

Each road has its own method as pertains to the inspection and maintenance of work on its locomotives. The engine house foreman is the main cog in the wheel in the efficient handling of locomotives in engine house. He must keep the general foreman or superintendent of shops posted at all times of conditions of power, and he should be able to give advance information concerning certain parts of the locomotive that will need renewing when engine is due for shop, such as cylinders, superheater headers, etc.

To maintain power it is necessary to give locomotive parts periodical inspections. In order to make a check of these inspections given, we have adopted the following method:

Monthly machinery inspection and work report on
Engine No. ....
Work done at .... Work done on ....
engine house date

1. Were both pistons disconnected from crossheads and examined for cracks?
2. Were piston heads and packing examined both sides? ....
3. Were both valves pulled, bushings examined and necessary work done? ....
4. Were necessary repairs made to crossheads and guides? ....
5. Were all rods removed and examined for cracks? ....
6. Were side rod bushings renewed? ....
7. Were main rod brasses renewed or reduced? ....
8. Were crank pins examined for cracks? ....
9. Was the necessary work done to shoes, wedges and binders? ....
10. Was necessary work done to valve gear? ....
11. Was necessary work done on engine truck? ....
12. Was frame examined for broken bolts? ....
13. Was necessary work done on trailer? ....
14. Was necessary work done on booster? ....
15. Was necessary work done to feed water pump? ....
16. Was feed water tube bundle washed? ....
17. Was lubricator cleaned? ....
18. Was train control and lighting systems inspected? ....
19. Was necessary work done on spring rigging? ....
20. Was necessary work done on brake rigging? ....
21. Was necessary work done on tender trucks? ....
22. Was necessary work done on tender frame? ....
23. Was necessary work done on water scoop? ....
24. Was necessary work done on tender brake rigging? ....
25. Was necessary work done on tank? ....
26. Were units tested? ....
27. Were perforated plates removed from driving box cellars and cleaned? ....
28. Were engine truck, trailer truck and tender brasses examined? ....

Signed ....
Engine House Foreman.

I believe that engine house foreman should also attend shop foremen's weekly meetings and criticize them for work not properly done in the shops, in particular work which will not pass Federal inspection, also the location of parts on which engineer will make complaints. The engine house foreman should consider it a privilege to attend these meetings and be able, by constructive criticism from maintenance experience, to advise the shop forces where they fail to turn out a locomotive which is equal to the demands of the service.

We request engine house foreman, assistant engine house foreman, engine house and shop boiler foreman, engine house engine inspectors, foreman of erecting floor, pipe foreman, general machine foreman and machine foreman of motion work, rod work and wheel work to ride engines, with instructions to observe the parts which they inspect or supervise and give a written report of their observations. We generally pick the run for these men to ride, with instructions to engine men to give them a good ride. We find this has a very good effect on supervisors and they realize the importance of their position and many good suggestions have been made and better work done.

Shop foremen meetings I am talking about are not the schedule meetings where we take up the matter of shop improvements, safety first questions, letters are read concerning all the foremen, articles discussed which appear in mechanical magazines, new devices explained which are located on engines, etc. At this meeting is a good time to take up such matters that will not pass federal inspections.

Federal and state standards present difficult problems and our officers have adopted many mechanical instructions to prevent their violation. There is no argument against the rules and standards as applied to locomotives by the Interstate Commerce and Public Service Commission. They have been instrumental in raising the condition of locomotives to their present high standard. Living up to these high standards has been one of our problems, but the fact should not be lost sight of that additional man hours are necessary to maintain the standards prescribed as compared with the time required before the creation of these public service bodies.

In conclusion let me put stress on this point, "That to obtain a higher standard of equipment maintenance, it is necessary that each of the physical conditions of your equipment be known and also know how to handle it. This may be done by keeping yourself posted, by noting how the other fellow handles this work, which information can always be found in the mechanical publications which are so numerous at the present time."

Electrification—A Tool of the Railroads

It Must Be Used Discreetly as It Will Not Solve All Problems

F. E. WYNNE, Manager, Railway Equipment Engineering, Westinghouse Electric & Manufacturing Company

The railroad is a manufacturer. It manufactures transportation. Manufacturers require tools. In its strictest sense a tool is defined as "A simple device, such as an ax or a spade, for use in working, moving or transforming material." The dictionary adds that "A tool is both contrived and used for extending the force of an intelligent agent to something that is to be operated upon." However, its meaning has been enlarged to include machines used in shop production. Such machines have been evolved to improve the speed, accuracy, efficiency and economy of manufacturing processes, largely made necessary by the demand for quantity production. Is it then unreasonable to designate as a tool that combination of energy, machines, appliances and structures constituting railroad electrification?

Now, what can electrification do as a tool? In its business of manufacturing transportation, the railroad is confronted with varying physical requirements for the several distinct classes of service. Each major division of traffic, passenger and freight, embraces several kinds of train operation. Electrification has been applied to practically every class of railroad service, so probably the best idea of its possibilities may be derived from a brief consideration of what it has done. The final instrument for utilizing electricity for train movement is the motive power, consequently locomotives and motor cars may be discussed to a greater extent than other elements of the electric system.

Several of the earliest applications of electrification were to do away with the emission along the right-of-way of smoke and gases which inevitably were present with steam locomotive operation. In cities smoke and gas from burning fuel are at least annoying and unsightly. They usually contribute to high maintenance of adjacent structures and furnishings. In tunnels and subways the discomfort and destruction are increased and in addition the element of danger to train crews and passengers is introduced. When tunnels are long or contain heavy grades, such danger becomes extreme even with the use of special coal and a high degree of artificial ventilation. The first electrification using locomotives was installed in tunnels of the Baltimore & Ohio R.R. for the purpose of eliminating these disadvantages of steam operation. The smoke nuisance was the exciting cause for the electrification of the Manhattan Elevated R.R. also. However, the motive power there takes the form of multiple-unit cars.

The demonstration of the practicability and sufficiency of electric operation in these and other cases led to the projection and construction of great subway systems, without which the local transportation situation in some large cities would be a nightmare. From subways it was but a step to the enormous underground railway terminal systems, such as the Penna. R.R. has in New York, and to the enclosure terminals, such as the Grand Central. Through the elimination of smoke and gases and the minimizing of the fire hazard, have such great works been made possible by electrification.

Suburban service has requirements quite similar to those of subways. Train size varies widely at different hours of the day, stops are frequent, and fast schedules are essential to attract and hold patronage. A steam locomotive which is adequate to handle the large rush hour trains is too large at other times. Hence, during a portion of each day in suburban service, such a locomotive operates at partial load and uneconomically. A steam locomotive of suitable size for the non-rush traffic is entirely inadequate during rush hours. Either size is wasteful of fuel during stand-by periods. On the other hand, the multiple-unit electric train with each car driven by its own motors has at all times power in proportion to the train size. A ten-car rush hour train can run just as fast as a two-car train. Also, when idle, the electric motive power unit consumes no fuel nor power. The Long Island Railroad was one of the first to take advantage of electrification to improve suburban service.

A steam engine is essentially a constant power machine and for maximum efficiency should be operated under a constant load. It is therefore an admirable tool for long hauls where tonnage can be adjusted to its capabilities and where its delivered power is approximately uniform whether running at low speed on heavy grades or at higher speed on moderate grades and level track. But in suburban service it suffers from poor efficiency due to the exceedingly variable load imposed upon it by the variable train size and frequent stops. The electric railway motor is inherently a variable power machine in which any demand for extra traction is met by the automatic development of increased power and it has a high efficiency throughout a wide range of load. This combined with the motorizing of each car makes multiple-unit operation a superior tool for suburban service.

Fast suburban schedules require a high rate of train acceleration just as your automobile must have a quick pick-up for satisfactory city driving with its numerous stops, both anticipated and unexpected. With trains, the sine quo non of rapid acceleration is weight on the driving wheels. A steam locomotive has a limited weight on drivers regardless of the weight of train behind it and hence the larger the train, the lower will be the possible rate of acceleration. The heaviest trains are necessary when the number of trains is greatest and a fast schedule is most desirable. The relatively low acceleration of locomotives under these conditions is a real handicap to maintaining adequate service in rush hours with steam power. The electric multiple-unit train often has as much as 65 per cent of the total train weight on its driving wheels. This is more than sufficient to permit the maximum comfortable acceleration on level track with a conservative factor of adhesion between wheels and rails. Evidently the Long Island Railroad has realized and appreciates these operating advantages of multiple-unit trains, for they have consistently extended their electric suburban service until, in 1926, they used 888 multiple-unit cars on 297 miles of electrified track to transport 100,000,000 passengers.

Multiple-unit operation possesses other interesting features which come primarily from the distribution of motive power through the train. For instance, the equipment is protected against extraordinary, expensive damage due to a single fault or failure, because the units of apparatus are relatively small. A defective car equipment may be cut out on the road without annulling the train. In fact, such action may not even cause an appreciable delay in arriving at the terminal. This is a valuable factor in protecting the service. Then, too, distributed power under the control of one engineman, through the absence of shocks and surges in starting, assures the comfort of passengers to a degree quite foreign to the customary steam-hauled suburban train. It is obvious, therefore, that electrification is the means of developing the highest class of attractive suburban service.

This type of suburban operation has proven immensely valuable in enlarging the track capacity of the stub-end terminal by eliminating train movements between the arrival and departure of the same train. Instead of moving the train and turning its locomotive in order to prepare it for a return trip, it is only necessary for the engineman and rear brakeman to interchange positions on the multiple-unit train. A measure of the value of this feature is found at the Broad Street Terminal of the Pennsylvania Railroad where suburban electrification reduced the number of movements 60 per cent with an attendant increase of 20 per cent in terminal capacity.

The second application of electric locomotives to steam railroad service was made by the Italian State Railways. The north of Italy is hilly to mountainous and consequently there was a measure of tunnel danger with steam operation in this locality also. But another major factor conducive to electrification entered here. Numerous heavy grades existed on these railroads, traffic was dense, and train size was (and yet is) limited by draft gear capacity. Additional tracks could have been constructed only at enormous expense. Electrification promised to relieve the congestion economically by utilizing higher train speed without increased engine crew expense and by reducing road delays due to motive power failures. Evidently electric operation fulfilled this promise, for the Westinghouse Company alone built over two hundred locomotives for the Italian State Railways.

Since electricity may be derived from water power as readily as from the combustion of fuel, electrification has been a real boon to some countries where fuel is scarce and expensive but where hydraulic sites are plentiful and reliable. The most notable example of such a situation is Switzerland where all coal must be imported but whose mighty Alps afford a huge and permanent water supply from their everlasting snows. However, economy is a minor factor there. The major inducement to electrify appears in its contribution to the State's independence and national security. Can you imagine any other country to whose nationals, with their glorious traditions, electrification would appeal so strongly? Is there any other nation where electrification is so vital to national defense? The answer is found in the fact that Switzerland's State Railways are scheduled for complete electrification and 70 per cent of their traffic is now handled electrically.

Scarcity of native fuel has been a compelling force to some extent in accelerating electrification in other European countries such as Italy, France, Norway and Sweden. In the upper part of the Scandinavian peninsula is a railroad which is thrice distinguished. It lies almost entirely north of the Arctic Circle, it operates the heaviest trains in all Europe, and it is electrified. While the fuel consideration entered here, one of the greatest benefits derived from electrification is the assured reliability of the service in severe weather. When the temperature reaches 50 degrees below zero, when there is twenty feet of snow, or when the humid atmosphere deposits six inches of frost on every exposed object, can you visualize what steam operation must have been? Could train delays have been avoided? Could steam locomotive crews have worked effectively? It is easy to understand that in this land of the midnight sun and noontide stars the entire railroad personnel highly appreciate electrification as a tool.

Increase in track capacity by electrification has been very forcibly demonstrated in the double-tracked Hoosac Tunnel of the Boston & Maine Railroad. With steam haulage only one passenger train at a time was permitted to enter this tunnel. Today three trains hauled by Baldwin-Westinghouse electric locomotives may be on each track within the tunnel without violating the rules. Sixty-two train movements daily are required by the average traffic while on peak days such movements have averaged more than one every fifteen minutes.

An important factor in railway operation is to have the motive power available for service continuously as nearly as possible. To be most economical, motive power should not require frequent or extensive repairs, for a locomotive in the roundhouse or back-shop is manufacturing no ton-miles. Triple duty is imposed upon the steam locomotive in that it is a generator of power, a transformer of energy, and a vehicle. The electric locomotive profits in comparison by not having to generate its own power. This absence of the fire-box and boiler from the electric unit is the chief element in keeping it in service a greater portion of the time. The premier example of this superiority of electric motive power is found in the record at the St. Clair Tunnel of the Grand

Trunk Railway. Its Baldwin-Westinghouse electric locomotives will be 20 years old this year. Throughout 1926, they were available for service over 97 per cent of the time. Do you know of any steam locomotive which has been unavailable for less than 9 days in a year?

The Chicago, Milwaukee & St. Paul Railway in its electrification of four engine divisions between Harlowton, Montana, and Avery, Idaho, gave actual proof of the feasibility and economy of the long engine run. Between the terminal points of the electric zone there were three steam engine terminals with roundhouses. For electric operation two of these engine terminals and roundhouses were abandoned thus reducing the four engine districts to two, the back-shop being located at the middle of the electrification. In fact, the locomotives are operated on what is virtually an 880-mile run between inspections. This abolishment of intermediate engine terminals and introduction of long engine runs on the Milwaukee electrification proved eminently successful and effected substantial economies. It also focused the attention of steam operators on the possibilities of this method of operation regardless of the type of motive power and led them to look about for means of adopting it. They have found that modern locomotives and improved standards of maintenance make the long engine run practical with steam locomotives, particularly if they are oil burners, and many railroads are now profiting from engine runs of such length that the mere mention of them would have been laughed out of court fifteen years ago.

I think we do not exaggerate when we claim that the adoption of long engine runs by the steam railroads has at least been accelerated by electrification as exemplified by the Milwaukee installation. Neither do I feel unduly optimistic in suggesting that electric passenger locomotives for reasonable speed (say 65 mph. maximum) can be designed today with such reliability that a single locomotive could haul its train regularly between New York and the Pacific Coast with no more inspection or adjustment en route than could be given during the time essential at intermediate points for changing engine crews and inspecting the cars.

The railroads have not seen fit to equip their switching locomotives with any device for recording mileage, which is difficult to determine accurately. As a basis for reporting performance and estimating unit costs, the Interstate Commerce Commission has specified the use of 6 mph. as the average speed. As a matter of fact, extensive observations in connection with electrification studies have shown that the actual average speed in switching is more nearly 3 mph. I believe that electrical engineers have materially assisted the railroad fraternity to a more exact understanding of their own conditions and problems and the foregoing is cited merely as one illustration of such contribution.

Effective switching requires a smart locomotive; a type that may be called a sprinter. Its movements are short and many are without trailing load. It works first here, then there; hence, it must start quickly and speed up rapidly. It should have the highest possible proportion of its total weight on its drivers. It is actually using power only 25 or 30 per cent of the time in service, hence it should consume a minimum of fuel or power when not actually developing tractive effort. It should be capable of continuous operation for long periods with a minimum of attention. Such attention should be required on the basis of work done rather than on the basis of time. Does the electric switcher or the steam switcher most closely approximate this ideal?

The electric switcher is inherently superior; for, in its simplest form it has all weight on its drivers; this total weight is effective from the adhesive standpoint in producing traction for quick starting; and the smoothness with which increments of power are applied assures the maintenance of maximum adhesion throughout the accelerating period; it consumes little or no power when not developing tractive effort; and it is not subject to frequent removal from service for taking fuel and water, cleaning fires and washing boilers. The most extensive application of electrification to yard switching is on the New York, New Haven & Hartford where 25 steam locomotives were displaced by 15 Baldwin-Westinghouse electric switchers which are in 24-hour duty and at times have operated for 30 consecutive days without interruption.

Electrification provides a means of removing the "bottlenecks" formed by heavy grades on mountainous sections of the railroads. Additional tracks in such territory are extremely expensive and in spots impossible. The first steps toward securing relief were double-heading, the application of heavier steam motive power and the addition of pusher locomotives, in the endeavor to increase the size of train and thereby reduce the number of movements for a given traffic with a resulting increase in track capacity. While these measures were effective in many instances, sometimes they proved abortive because of extra difficulty in handling the larger trains and the great number of light engine movements introduced.

Prior to electrification, the Norfolk and Western Railroad at times of heavy traffic found it necessary to use three locomotives on each train up the mountain and to operate so many trains and locomotives that they were actually in each other's way. Many trains ascended the grade without exceeding a speed of 7 mph. Broken knuckles and pulled drawbars were of almost hourly occurrence. Often three trains were lined up close together behind a water tank or coaling station. The operation of freight trains was so uncertain that at times they were held for hours at some point on the hill waiting for a following passenger train to pass. Electrification with Baldwin-Westinghouse locomotives changed all this. Heavier trains are now handled by only two locomotives. The speed up the grade is constant at 14 mph.

Train breakages are relatively infrequent. The operation of freight trains is so reliable that it is common practice to dispatch a freight up the hill just a few minutes ahead of a passenger train without any fear of delay to the superior traffic.

Much of the risk in train movement, much of the punishment to rolling stock, and many of the delays to traffic are part and parcel of down-grade operation. In regenerative braking, electrification affords the railroads a remedy for such of these ills as may not be due to man-failure, poor track or defective cars. The regenerative locomotive holds the train at the desired safe speed by the continuous application of just the right braking power. Effective use of regeneration requires less skill on the part of the engineman than does the air brake. The intermittent application of braking power which is necessary when air is used on long grades is, at its best, a potential source of shocks and surges which often produce break-in-twos.

The continued rubbing of brake shoes on wheels strains car trucks and brake rigging and wears out shoes and wheels with resulting expense for repairs. Regenerative braking within the capacity of the locomotive does away with such undesirable features of usual operation and with no corresponding penalty. Incidentally regeneration returns more or less power to the line to assist other trains which may be drawing power for level or up-hill running, thus reducing the amount of energy which must be generated or purchased by the railroad. Prominent among those railroads which are daily benefiting by the use of regeneration is the Chilean State Railway which employs it on both passenger and freight trains.

About 10 years ago the Virginian Railway was considering electrification as a means of relieving the congestion which even then existed between Elmore and Princeton. The service conditions and operating costs with steam locomotives were analyzed and careful estimates made of the initial and operating costs with electric power. These showed that electrification could produce the desired operating improvements profitably. The railroad also investigated the possibility of dividing the heavy grade Clark's Gap hill up into several low grade sections operated by steam locomotives and connected by inclined planes up which the cars would be lifted by hoisting engines. A certain amount of such inclined plane operation had been successful in the anthracite coal fields for years.

Before the railway reached a conclusion regarding the suggested new methods of operation, the United States entered the Great War and this project, in common with a number of others then active, was set aside in order to meet the emergency quickly by the more familiar methods of double tracking and utilization of improved steam locomotives. Six years later the railway contracted for the electrification of their line between Roanoke and Mullens, 135 miles, including 33 Westinghouse motive power units for the operation of freight trains. The passenger service has been continued to date with steam locomotives.

Perhaps it is fortunate for all those concerned that this period intervened between the initial study and the actual work, for meanwhile the technique of electrification and the construction of electric motive power advanced materially, the railway's roadway had become more seasoned, they had demonstrated the practicability of operating enormously heavy trains, and traffic density had grown by leaps and bounds. The net result is that today the Virginian Railway owns and operates the largest and most powerful locomotives of any kind in the entire world and these monster engines are electric.

The change in type of motive power and the accompanying modifications in operating practices were made with a minimum of disturbance, due to several factors. In the first place the railway, their consulting engineers and the manufacturers, not only collaborated but co-operated to perfect the application, design and construction of the new equipment. Then, when the locomotives were under construction, several men from the railway's maintenance and transportation departments were assigned to the manufacturers' works as inspectors and for instruction regarding the details, maintenance practices and operation of electric motive power. Finally, as the units were received on the railroad, time was taken to put selected steam enginemen and firemen through a definite course of instruction with examinations relating to the apparatus, its purpose and its functioning, together with practice in and tests on the manipulation of the new power in service. Upon his successful completion of this course, a candidate was qualified as an electric locomotive engineman or helper.

The Virginian Railway has ever been a pioneer. In the original plan, its builders recognized the fundamental principle that although the initial cost may be high, a low grade straight line saves in operating costs each year and every year. Consequently, the entire section from Roanoke to Norfolk was constructed with easy curves and a maximum grade of 0.2 per cent against the loaded movement. West of Roanoke the character of the country is such that heavier grades could not be avoided economically. However, the same character of analysis and search for economy in operation has been used continually by the railway and they have had the courage to act on the basis of the conclusions reached by such analysis. The result has been that the Virginian Railway has been in the lead in the utilization of large cars and heavy motive power and in the operation of large trains. Their electrification plans followed the same progressive lines and they purchased locomotives suitable for operating heavier trains at higher speeds than were secured with steam power.

In the operation of 6,000-ton trains up Clark's Gap Hill at 14 mph. with two triple-unit electric locomotives, the Virginian has the distinction of employing the world's greatest concentration of motive power on a single train. Further, the locomotives are so arranged that four units may be used as one locomotive when conditions warrant it and the utilization of this feature will permit the operation of trains one-third greater than at present.

Another indication of this railroad's practice of looking out for the future appears in the provisions for contact line voltage. The standard pressure applied on heavy single-phase trolley lines in America for twenty years has been 11,000 volts. Abroad, potentials of 15,000 to 16,000 volts have been most common for such lines. In view of the probability of greatly increased tonnage from the rich coal fields tapped by this railroad and because of the larger and more frequent trains which will be required to handle this future development most economically, the Virginian had their contact line built for 22,000 volts and the locomotives and substation equipment arranged for either 11,000 or 22,000 volts. The present operation at 11,000 volts is meeting all of the requirements to date.

The Virginian Railway is primarily a coal road. The coal fields are near the western end of the line. The major portion of their output is delivered to Tidewater at Norfolk for sea shipment. The Elmore yard, near the western terminus of the electric zone, is the point at which loaded cars are collected for this eastbound movement in trains weighing 6,000 tons, excluding the locomotive weight. One electric locomotive at the head of the train serves as the road engine for the entire run from Elmore to Roanoke. When leaving Elmore, a second locomotive is coupled to the rear of the train as a pusher which helps to operate the train up the 14-mile hill with over 1,000 ft. rise to Clark's Gap. At this point the pusher is cut off and the train is filled out to 9,000 tons by taking from the side tracks cars which have been brought this far from Elmore by hill crews and engines operating between that point and Clark's Gap only. The electric road engine handles this 9,000-ton train all the way from Clark's Gap to Roanoke without assistance.

Leaving Clark's Gap the train is held by regenerative braking on the down grade to Rock and is then hauled up grade through Princeton. Maximum regeneration is brought into play down the Kellysville hill after which the duty is relatively easy until the train reaches Whitethorn where the heaviest grade against the 9,000-ton train begins. This grade is 0.585 per cent for 10 miles and is followed by the 8-mile descent of the east slope of the mountain on an average 1.25 per cent grade where heavy regeneration again comes into action. From Fagg to Roanoke is down a light grade, much of which may be covered at a speed of 28 mph. The westbound movement is composed principally of empty cars.

With steam power, three mallet locomotives handled trains of 5,500 tons from Elmore through Clark's Gap to Princeton; one steam road engine handled trains of 8,500 tons from Princeton to Roanoke. The assistance of a yard engine was usually required to get out of Princeton yard and a mallet pusher was necessary from Whitethorn to Merrimac. The speed up the heavy grades was less than seven mph. On Clark's Gap hill the 9 per cent heavier train is now handled at double that speed with electric locomotives having 11 per cent more weight on drivers but with only 1.5 per cent more total weight. On Whitethorn hill the train weight is now 6 per cent more than with steam operation, while the weight on drivers is 11 per cent less and the total weight of locomotives per train is 13 per cent less. Out of fairness to the steam operation, it should be noted that while electrification was being installed, the heavy steam power which was gradually released from hill service was utilized temporarily to haul trains of from 10,000 to 13,500 tons from Princeton to Roanoke.

In short, at the critical points on the road the electric locomotives are handling practically the same weight of train per ton of locomotive and doing this at twice the speed of steam operation. These comparative figures are given in no spirit of disparagement of the wonderful performance of steam power, but that you may recognize that in electricity the railroads have available a superior tool for use in solving many of their difficult transportation problems.

About 20 years ago, the Great Northern Railway electrified with beneficial results, their 2.63 mile Cascade tunnel along lines similar to those used by the Italian State Railways. In spite of this, the crossing of the Cascades continued to be the bottle-neck of the railroad on account of the severe grades, tortuous alignment and numerous snow-sheds along the approaches to the tunnel. Several years ago they decided to build a new tunnel nearly 8 miles long between Scenic and Berne to eliminate these difficulties. The expectation is that this tunnel will be completed by the end of this year. It will decrease the distance 7⅔ miles, cut out 1950 degrees of curvature and eliminate 6 miles of snow sheds. Furthermore, the maximum elevation on the new line is 506 feet below the former peak. Of course, in making this improvement, the railroad determined upon the use of electric motive power in the tunnel and their studies indicated that the greatest economy would be derived from electric operation of the entire engine district.

Meanwhile, a new type of electric locomotive had been developed and successfully applied by Westinghouse on the Detroit, Toledo and Ironton Railroad. This type, the motor-generator locomotive, develops constant horsepower over a wide range of speed, thereby approaching the characteristics of the steam locomotive more nearly than any previous electric type. It also lends itself readily to regenerative braking. This type appealed to the Great Northern Railroad as being best adapted to their service conditions. While they desired substantial duplicates of the D. T. & I. units electrically, they preferred a mechanical design along more conventional lines. Consequently, instead of waiting for the completion of the long tunnel, they ordered motor-generator locomotives to operate over the present line between Skykomish and Cascade.

The first of the new Great Northern locomotives was placed in service over a year ago. The ruling grade is 2.2%. Even after the new tunnel is completed this grade governs on 12 miles against eastbound traffic and on 7 miles westbound. With steam power, one Mikado road engine and two Mallet helpers handled a 2500-ton train. Two electric locomotives handle a 2800-ton train on the up grade and one holds 2500 tons on the down grade by regenerative braking. An interesting illustration of the electric locomotives overload capacity was found when two of these engines in an emergency hauled a 3500-ton train and a dead Mikado steam locomotive up 7 miles of the heavy grade. On the present 26 miles of electrified track each of these locomotives operated approximately 60,000 miles in the first year. The operation contemplates 3500-ton trains ultimately with one two-unit road engine and one three-unit helper and with more trackage electrified, greater mileage per locomotive may be confidently predicted.

At this point it may be well to note that electrification usually reduces the non-revenue ton-mileage operated by the railroad. If the road generates its own power, the amount of fuel used for traction is less than if it were burned on steam locomotives, and it is likely to be hauled a shorter average distance. If energy is from water power, the haul of fuel for traction is eliminated. If energy is purchased from a steam plant, the non-revenue-producing haulage of fuel is not only done away with but may even be replaced by revenue-producing haulage to the steam plant. Thus not only do direct economies in cost of operation result but the tracks are relieved of a certain unproductive burden and their capacity for profitable service is increased to that extent.

It was early appreciated that the elimination of smoke and gases and the reduction of noise from motive power together with the more rapid and reliable service would increase urban property values in the immediate neighborhood of an electrification. However, it was some years before it was realized that in very congested districts, such as surround large city railway terminals where property is already ultra-valuable, the railroad could profit very materially by either utilizing or leasing its air rights above the terminal tracks for building purposes. The best example of such development is adjacent to the Grand Central Terminal in New York. The influence of this by-product of electrification has been so far reaching that now air rights are being leased at steam operated terminals for the erection of buildings specially designed to provide for the disposal of the smoke and gases given off by the steam locomotives beneath them.

I think it was James J. Hill, the great empire builder of the Northwest, who first enunciated the principle that railroad operated expenses are a function of the train-miles operated, while railroad revenue is determined by the ton-miles handled. When we recognize that operating costs are largely made up of crew wages, repairs and fuel and that these are to a great extent independent of the size of train, it is obvious that Mr. Hill made a very concise and accurate statement. For years, this principle has been accepted as gospel by many railroad men and they have continuously increased motive power units and train weights in the effort to reduce operating expenses. Recently, however, they have been giving greater attention to another unit as an improved measure of cost, i. e., ton-miles per train hour. This unit recognizes the value of speed. Formerly, speed had been ignored or overlooked frequently, with the result that locomotives were loaded to the limit of their tractive power. This often limited the train speed to the point where delays became intolerable and unit train costs were pyramided far beyond the point of maximum economy from the standpoint of over-all costs.

It was once common practice among the railroads to compare locomotives and determine their relative merits largely on the basis of maintenance costs per locomotive-mile. This is obviously incorrect when we consider that locomotives vary so widely in type, size and ability to produce ton-miles. Consequently, locomotive maintenance came to be evaluated in cents per locomotive-mile per ton on drivers and also per 1000 ton-miles produced. Probably the fairest basis will be cost per 1000 ton-miles per train-hour as such a unit will take account not only of the work done but also of the rate at which it is done.

These two instances of changes in the railroads' method of thinking and analysis are mentioned because: first, studies of electrification have had an influence on the railroads' way of estimating economics and; second, the results of electrification have stimulated steam locomotive partisans in the design and operation of steam power until the steam locomotive of today embodies features of design and gives operating results unhoped for ten or fifteen years ago.

Much to the regret of electrical engineers (and many city politicians) electrification is an expensive undertaking. The initial cost is the great deterrent in most cases where it fails of adoption after careful, honest consideration. Of course, at times studies of electrification have been made for lines whose conversion to electric operation could not be justified by even the most elastic imagination. Usually in such cases the lacking element was density of traffic and electrification could be considered only as an unwarranted luxury. I think I am safe in saying that there is a limit in traffic density below which electrification will not pay. This limit will not be the same in all instances. For example the limit for a single track line will be quite different from that for a four track system; or the limits for level and mountain districts of the same line will differ widely.

Nevertheless, electric traction apparatus is finding a field at the lower end of the traffic scale; that is, on branch lines and in main line local service. This field is being served now by cars and locomotives using the internal combustion engine to drive a generator which in turn drives electric traction motors. While a considerable number of such units are in successful operation already, we must yet consider this development young and promising. If it becomes as sturdy an adult as its advocates hope, we may in time see steam power in a middle position being squeezed between this form of motive power and full electrification.

Like all good tools, electrification must be used with discretion. It is not wise to use a hatchet to cut nails nor a chisel to drive screws. So electrification should not be expected to solve all the problems of railroading. However, I can and do commend it to you as a superior tool worthy of judicious application and capable of remarkable accomplishment in intelligent hands.

New Electric Locomotives for Sacramento-Northern Railroad Operate on Three Different Voltages

By W. R. TALIAFERRO, Railway Equipment Engineering Department, Westinghouse Electric & Manufacturing Company

Two new 68-ton electric locomotives recently placed in service on the Sacramento-Northern Railroad are arranged for operation on three different voltages. This unusual feature will enable them to be used on the present system where power is collected from either a 1200-volt overhead or a 600-volt third rail and on an extension of the system which is under way, where a 1500-volt trolley will be used.

Including the two new locomotives, the Sacramento-Northern Railroad is now operating 14 electric locomotives ranging in size from 42 to 68 tons. The first of these were placed in service nine years ago. Recent figures on their operation over this period show excellent results.

AVERAGE COSTS, CENTS, PER LOCOMOTIVE MILE

	1918	1919	1920	1921	1922	1923	1924	1925	1926
34 Equipments......	4.90	8.18	7.69	6.70	6.18	6.33	3.65	3.95	4.33
67 Supplies..........	0.27	0.41	0.81	0.30	0.27	0.23	0.27	0.17	0.14
70 Inspection........	0.78	0.89	1.35	0.78	0.43	0.45	0.62	0.50	0.57
Total	5.95	9.48	9.85	7.78	6.88	7.01	4.54	4.62	5.04
Mileage	217276	241278	237545	215426	241391	234933	233938	269821	315897

These figures are amazingly low when it is considered that a locomotive mile, as far as the locomotive costs are concerned, represents a train mile which amounts to 1500 tons trailing load in the busy season.

Among the 12 locomotives from whose service performance the above figures were compiled are two 60-ton Baldwin-Westinghouse locomotives which, in 1925, were operated for 2.83 cents per locomotive mile.

The two new locomotives are arranged for essentially full speed operation on any one of the three voltages when power is being taken from either a third rail or an overhead wire.

In order to obtain efficient acceleration and full speed at all voltages the traction motors are grouped in three motor combinations; namely, series, series-parallel and parallel. The parallel combination, however, is not used when operating on 1200 or 1500 volts.

The motors are arranged for both full and short field operation. The changeover is effected by means of a group of cam-operated switches controlled by an electro-pneumatic air engine.

By means of a current limit relay and suitable control circuits the short-field connection is obtained in any short field notch on the master controller only when the current drawn by the traction motors is below a predetermined value, thus releasing the power system from heavy loads while the locomotive is delivering large tractive forces. The control is so arranged that once the motors are connected for short-field operation they remain so regardless of changes in current until the master controller handle is moved to a full field position.

The master controller is of the single-pull type, has 27 notches, an "off" position and two transition spaces. It contains the usual interlocking features of a two-speed controller and in addition is electrically interlocked with the rest of the electrical equipment to prevent the parallel motor combination from being set up when the locomotive is operating on the higher voltages.

By means of selective relays the locomotive is arranged to changeover automatically, while in motion, from third rail to trolley operation, or the reverse, and from 600- to 1200- or 1500-volt operation.

The changeover between trolley and third rail at the same voltage can be made without the use of a dead section, provided trolley and third rail are tied together in the power system. The changeover from one voltage to another is always made on a dead section over which the locomotive must coast.

The trolley-shoe changeover equipment consists of two relays, an electro-pneumatic changeover drum and a set of unit switches. One relay is connected to the trolley circuit while the other is connected to the shoe circuit. To effect a changeover, one relay must be energized while the other is de-energized, under which condition the changeover drum is thrown over by its air engine to the trolley or show position as determined by the relay which is energized at the time. When both relays are energized or de-energized no changeover occurs.

The changeover drum carries main contacts for connecting the auxiliary apparatus to the trolley or shoe circuits as required, and interlock contacts which set up control circuits which cause the proper unit switches to close for connecting the main motors to the trolley or shoe circuits.

The 600- to 1200- or 1500-volt changeover equipment consists of a high and a low voltage relay, a drum type changeover for connecting the double voltage compressors and dynamotors for 600- or 1200-volt operation and a push button at each engineman's position.

The air engine of the changeover drum is equipped with a standard and an inverted magnet valve which always cause it to throw to the high voltage position when the magnet valves are de-energized, thus assuring that the locomotive will be in the safe or high voltage connection or will throw to this position should power be removed from the locomotive through failure or any other cause.

The low voltage relay makes contact when energized and the high voltage relay makes contact when de-energized. The low voltage relay is set to lift at 300 volts and to drop at 200 volts, and the high voltage relay is set to lift at 750 volts and to drop at 200 volts. The contacts of these two relays, the two magnet coils of the changeover drum and a push button on the meter panel in each engineman's compartment are connected in series with a source of control power.

In order to understand the operation of the changeover equipment assume that the locomotive is running on a 600-volt line and about to run onto a dead section between the 600-volt line and a 1200- or 1500-volt line. The low voltage relay is lifted, the high voltage relay is down and the changeover drum is thrown to the 600-volt position because the magnet valve coils are energized. Upon reaching the dead section the low voltage relay will drop since it is de-energized and the changeover drum will throw to the 1200-1500-volt position because the magnet valve coils are de-energized. A few seconds later the locomotive will reach the 1200- or 1500-volt line, both relays will pick up, as the voltage is above 750. No further change will take place since both relays are lifted and the circuit broken.

Assume that the line voltage fails. The changeover will remain in the high voltage position if the locomotive is operating on a high voltage line or throw to that position if not already there. Hence any failure places the equipment in the safe or high voltage connection.

Assume that the line voltage has become abnormally low (below 200) both relays will then drop but no change in the position of the changeover drum will occur if operating on a 1200-1500-volt line. If operating on a 600-volt line the changeover drum would throw to the safe or 1200-1500-volt position. However, if the line voltage of a 1200- or 1500-volt line, after falling to zero, would rise to between 300 and 750 volts, the low voltage relay would close. The changeover would then throw to the 600 volt position were it not for the push button on the meter panel in each engineman's compartment which still holds the circuit to the changeover drum magnet valves open. In this manner it is made impossible for the locomotive to be placed in the low voltage connections by false operation of the changeover equipment while on a high voltage section with low voltage on the line.

Assume that the locomotive is moving from a high voltage section over a dead section to a low voltage section. Upon reaching the dead section both relays drop, but since the changeover is already in 1200-1500 volt position no changeover takes place. Upon reaching the 600-volt section the low voltage relay lifts. No changeover is effected, however, until the engineman presses the push button on the meter panel completing the circuit and causing the changeover to throw over to the 600-volt position where it is held by air as long as the low voltage relay remains energized and the high voltage relay remains down.

Pressing the push button while operating on a 1200- or 1500-volt line has no effect on the changeover as the circuit is held open by the high voltage relay being lifted.

When operating on from 1350 to 1500 volts, a voltage relay functions to open magnetic contactors inserting re-

Electric Locomotive of the Sacramento Northern Railway Built by Westinghouse Elec. & Mfg. Co., and the Baldwin Locomotive Works sistance ahead dynamotor and compressor motor. The traction motors are designed to operate on 1200 or 1500 volts when two are connected in series.

Each of the four motors is protected against overloads by means of an overload trip relay, which when tripped, cause resistance to be inserted into the circuit to cut down the current and then causes the line switches to open.

Each third rail shoe and trolley circuit is equipped with a railway type magnetic blowout fuse box.

The trolley circuit is protected from lightning by an electrolytic lightning arrester.

All lighting and auxiliary motor circuits are protected by fuses.

The traction motors are each equipped with a contact-making thermometer sealed in a brass tube and inserted in a copper cell which is in turn embedded in the field winding. Leads from these thermometers are carried into the cab to a relay which functions to take power off the motors should they reach a predetermined maximum temperature for which the thermometers are set. This relay and cutout switch are mounted in a sealed steel box. If it is essential to operate the locomotive even with hot motors the seal may be broken by the engineman and the switch closed, thereby restoring power.

In addition to the temperature trip relay and thermometers, the locomotives are equipped with temperature indicators which give the engineman a continuous indication, electrically, of the temperature of the motors as long

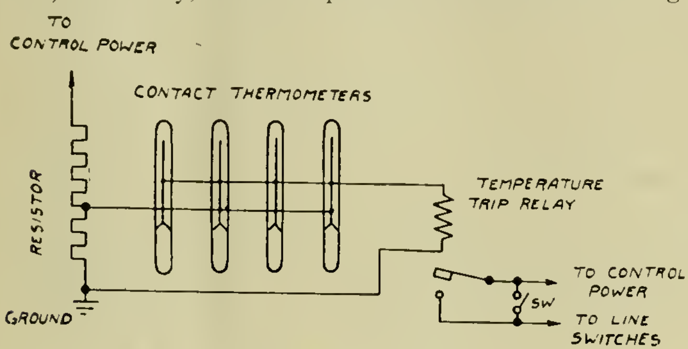

Diagram of Temperature Trip Equipment

as they are taking power. An accompanying diagram shows this equipment connected in a standard Wheatstone bridge circuit of which the motor field is the "X" leg, the shunt the "A" leg and the resistance box the "B" and "R" legs.

The principal auxiliary apparatus consists of the following:

Type 14-EL independent and automatic air brake equipment including two type D-4-N double voltage compressors of 50 cubic foot capacity each.

Two dynamotor blower sets for ventilating the traction motors and for supplying power at 600 volts for control, lights and heater circuits.

Four 2000 watt cab heaters.

Two electric classification lamps.

Two high power headlights.

Two pneumatic window wipers.

Four third rail shoes.

One pantagraph.

Space is provided on the roof to mount a wheel trolley, in addition to the pantagraph if desired.

Mechanical Parts

The mechanical parts are modified in class D, Baldwin-Westinghouse design, consisting of two four-wheel swivel trucks and a steeple type cab, under the hoods of which are mounted the dynamotors, blowers and compressors. The cab contains two operating compartments with engineman and helper's positions, a central equipment compartment containing the accelerating resistors, unit switches, reversers, changeover switches, etc.

Beneath the cab, and between the trucks, are located two of the main air reservoirs, the brake cylinder and brake slack adjuster. On the roof of the cab are located two main air reservoirs, pantagraph grounding switch, a pantagraph and the locomotive whistles. The headlights are carried on top of the hoods. One bell, air and hand operated, is carried on one hood.

Ratings and Dimensions

The locomotives have the following ratings and dimensions:

600-1200-Volt Ratings—Forced Ventilated

Field	Hp. at Rail	T. E.	Mph.	Motor Amps.
S. F. Hourly	1010	21800	17.4	356
F. F. Hourly	928	24000	14.5	331
S. F. Cont.	744	13800	20.2	260
F. F. Cont.	705	16000	16.5	245

1500-Volt Ratings—Forced Ventilated

Field	Hp. at Rail	T. E.	Mph.	Motor Amps.
S. F. Hourly	1180	19400	22.8	330
F. F. Hourly	1100	22000	18.8	310
S. F. Cont.	932	13600	25.7	260
F. F. Cont.	890	16100	20.7	245

Maximum Safe Speed .... 35 Mph.
Maximum Tractive Effort..45300 lb. at 33⅓% adhesion.

DIMENSIONS

Length between coupler knuckles....	37 ft., 11½ in.
Length over bumpers..............	34 ft., 4 in.
Height over roof..................	12 ft., 0¼ in.
Height over pantagraph (down)....	16 ft., 0¼ in.
Height of draw bar................	34½ in.
Total wheel base..................	25 ft., 0 in.
Rigid wheel base..................	7 ft., 4 in.
Wheel diameter....................	36 in.
Width over cab sheets.............	10 ft., 0 in.
Gauge	4 ft., 8½ in.
Gear ratio........................	18.68

The mechanical parts for these locomotives were built by the Baldwin Locomotive Works. The electrical equipment was built and the complete locomotives assembled by the Westinghouse Electric & Manufacturing Company and shipped on their own wheels to California.

Notes on Domestic Railroads

Locomotives

The Seaboard Air Line is inquiring for 25 Mikado type locomotives.

The Minneapolis, St. Paul & Sault Ste. Marie Railway contemplates buying 8 Mountain type locomotives.

The Canadian National Railways has ordered 12 snow plows from the Eastern Car Company.

The Uintah Railway has ordered one 2-6-6-2 Mallet type locomotive from the Baldwin Locomotive Works.

The Southern Railway has placed order for sixty-eight locomotives with the Baldwin Locomotive Works.

The Chicago, West Pullman & Southern Railroad is inquiring for a six-wheel switching locomotive.

The Southern Pacific Company is inquiring for 16 locomotives.

The Akron, Canton & Youngstown Railway is inquiring for 2 Mikado type locomotives.

The New York Central Lines has ordered 5 Hudson 4-6-4 type locomotives and 5 suburban 4-6-6 type locomotives from the American Locomotive Company. These locomotives are for service on the Boston & Albany.

The City of Seattle, Washington has ordered a Prairie type locomotive from the Baldwin Locomotive Works.

The Chicago, St. Paul, Minneapolis & Omaha Railway is inquiring for eight 8-wheel switching locomotives.

The Atchison, Topeka & Santa Fe Railway is inquiring for 15 locomotives from the Baldwin Locomotive Works.

The Michigan & Limestone Chemical Company has ordered 2 six-wheel switching locomotives from the Baldwin Locomotive Works.

The Illinois Terminal Company has ordered a Mogul type locomotive from the Baldwin Locomotive Works.

Passenger Cars

The Chicago, Milwaukee, St. Paul & Pacific Railroad is inquiring for 10 all steel baggage and mail cars; 10 all steel passenger coaches; 10 all steel suburban coaches; 1 all steel baggage car; 11 all steel gas-electric motor cars.

The St. Louis-San Francisco Railway has ordered 5 gas-electric rail motor mail and baggage cars to be equipped with Electro-Motive Company's single 400-hp. power plants. The car bodies will be built by the St. Louis Car Company.

The Canadian National Railways has ordered 69 cars for passenger train service as follows: 5 cafe parlor cars, 2 buffet club cars and 30 colonist cars from the Canadian Car & Foundry Company; 12 baggage cars and 20 colonist cars from the National Steel Car Corporation.

The Chicago Rapid Transit Company is inquiring for 150 motor cars and 150 double-end trailers.

The Southern Railway has placed order for 25 all steel mail and baggage cars for delivery in the early spring and summer.

The Illinois Central Railroad is now inquiring for 10 motor cars and 10 trailers for suburban service.

The Missouri-Kansas-Texas Lines is inquiring for 8 combination mail and baggage cars.

The Chicago, South Shore & South Bend Railroad is inquiring for 10 interurban cars.

The Northern Pacific Railway is inquiring for 4 gas-electric rail motor cars.

The Chicago, Burlington & Quincy Railroad has ordered six baggage and three passenger baggage cars from the Pullman Car & Manufacturing Corporation.

The Richmond, Fredericksburg & Potomac Railroad is inquiring for 1 cafe parlor car.

The Boston & Maine is inquiring for 10 combination baggage and mail cars.

The New York Central Lines has issued inquiries for 119 passenger train cars for services on the various lines of the system.

The Chicago, Aurora & Elgin Railroad is inquiring for 10 interurban cars.

The Chicago, Rock Island & Pacific has ordered 10 coaches from the Pullman Car & Manufacturing Corporation, 10 suburban cars from the Standard Steel Car Company, 10 baggage and 6 baggage and mail cars from the American Car & Foundry Company.

Freight Cars

The Anglo-Chile Nitrate Company has ordered 50 flat cars from the American Car and Foundry Company.

The Pacific Fruit Express has ordered 1,000 refrigerator cars from the Pullman Car & Foundry Company and 1,000 from the Pacific Car & Foundry Company.

The St. Louis-San Francisco Railway is inquiring for 250 underframes.

The Norfolk & Western Railway will rebuild 250 all-steel 90-ton gondola coal cars at its Roanoke shop.

The Baltimore & Ohio Railroad is reported to have placed 2,000 steel box car bodies with Standard Steel Car Company.

The Booth & Flinn Company, Pittsburgh, Pa., has ordered 32 gondola cars from the Bethlehem Steel Company.

The American Smelting & Refining Company has ordered 60 steel gondola cars of 30 tons' capacity from the Koppel Industrial Car & Equipment Company.

The Chicago, Burlington and Quincy Railroad has ordered 150 ballast cars from Rodger Ballast Car Company.

The Fruit Growers Express is inquiring for 1,200 steel underframes.

The North American Car Corporation has ordered 3,000 refrigerator cars from the Pressed Steel Car Company and is inquiring for 500 8,000-gallon capacity tank cars.

The Lehigh & New England Railroad has placed orders with American Car & Foundry Co. for repairs to 200 50-ton hopper cars.

The Western Union is inquiring for 5 steel underframes and trucks for 50 ft. box cars of 40 tons' capacity.

The Chinese Eastern Railway Commission will receive bids on May 2 at Harbin, China, for 660 closed goods wagons, of 25 tons' capacity, with two axles, and for 330 wagons, of 50 tons' capacity, with four axles.

The Norfolk & Western Railway will build 250 gondola cars and 30 locomotive tenders at its Roanoke, Va., shops.

The Aluminum Company of America has ordered one 8,000-gal. capacity experimental tank car from the Standard Tank Car Company. The tank and all its fittings will be made of aluminum in order that service tests may be made to determine the advantages of this material from a corrosion-resisting standpoint.

The Southern Railway has placed orders for 3,000 coal cars, 2,250 automobile box cars, 250 ballast cars, 200 caboose cars.

The Canadian National Railways has ordered 60 Hart-Otis ballast cars, from the Canadian Car & Foundry Company, and 200 from the Eastern Car Company.

The Pacific Fruit Express is inquiring for from 450 to 800 steel underframes for refrigerator cars.

The State Railways of Uruguay have made inquiry for 10 box cars, 32 stock cars and one auxiliary crane.

The Chicago, Milwaukee, St. Paul & Pacific Railroad has ordered 200 ore cars from the Pressed Steel Car Company.

The Safety Car Heating & Lighting Company has ordered 30 special refrigerator cars without ice bunkers from the American Car & Foundry Company.

The Protane Corporation, Erie, Pa., has ordered 3 tank cars from the General American Tank Car Corporation.

The Amtorg Trading Corporation is inquiring for 15 flat cars.

The Detroit & Toledo Shore Line is inquiring for 192 gondola cars of 50 tons' capacity.

The Southern Pacific Company is inquiring for 10 dump cars.

The Chicago & North Western has ordered 500 automobile car bodies from the Standard Steel Car Company and 500 from the General American Car Company.

The St. Louis-San Francisco Railway has ordered 6 air dump cars from the Magor Car Corporation.

The Seaboard Air Line is inquiring for 500 steel underframes.

The Pittsburgh Steel Company has ordered 3 butt cars for plant service from the Pressed Steel Company.

The Northern Pacific Railway is inquiring for 50 caboose car underframes.

The Union Refrigerator Transit Company has ordered 50 refrigerator cars from the American Car and Foundry Company.

The Minneapolis, St. Paul & Sault Ste. Marie Railway has ordered 200 box cars from the Pullman Car & Manufacturing Corporation and 200 from the Seims-Stembel Company.

The Southern Pacific Company is inquiring for 250 automobile cars and 175 tank cars.

The Atlantic Coast Line is inquiring for 200 phosphate cars.

Supply Trade Notes

The Royal Railway Supply Company, Inc., has removed from 35 Fifth avenue to 90 West street, New York.

R. O. Schaffer representative of the **Verona Tool Works**, Chicago, has resigned to become assistant sales manager of the **Du-Wei Steel Products Company**, with headquarters in the Railway Exchange Building, Chicago.

A. L. Whipple, who formerly represented the Locomotive Stoker Company is now a district sales manager for **The Standard Stoker Company, Inc.**, with offices at 350 Madison avenue, New York City.

Carl F. Gehlen has been appointed assistant to manager railway sales department, of the **E. I. DuPont de Nemours & Co., Inc.**, with headquarters at Parlin, N. J.

J. A. Mayer has been appointed manager of the **Graybar Electric Company**, with headquarters at Oklahoma City, Okla. **R. W. Conrad** has been appointed sales manager of Tulsa, Okla.

The Globe Steel Tube Company, Milwaukee, Wis., has opened a district sales office in the Engineers' Bank Building, Cleveland, Ohio, in charge of **W. S. Carson.**

P. P. Barrett, has been appointed representative for the **Reading Iron Company**, with headquarters at Indianapolis, Ind.

The Hammond Bolt & Nut Co., Hammond, Ind., has bought the bolt, nut and rivet department formerly owned and operated by the **Illinois Car & Manufacturing Co.**

H. S. LaBarge, manager of railway sales of **The Glidden Company**, Cleveland, Ohio, has transferred his headquarters to St. Louis to take charge and develop railway sales in the Southwestern territory.

Paul Willis has been elected a vice-president of the **J. S. Coffin, Jr., Company**, Jersey City, N. J., having resigned his position as district manager of the **Franklin Railway Supply Company, Inc.**

F. C. Pray, who was in railroad supply department work and connected with a bureau of material supplies under the railroad administration, now heads the **Twin City Railroad Hoe Company** of Minneapolis, Minn.

E. J. Shuler has joined the staff of engineers of **The Fusion Welding Corporation**, Chicago, Ill. Mr. Shuler has been for the past eight years in charge of welding for the **New Orleans Public Service Corporation.**

C. E. Preble, who has had charge of the engineering department of the **Heywood-Wakefield Company**, at Wakefield, Mass., has been appointed assistant to **Bertram Berry** in the railway sales department at New York.

B. F. Fairless, vice-president and general manager of the **Central Alloy Steel Corporation**, Massillon, Ohio, has been elected president and general manager. He will be succeeded by **S. S. French**, president of the Berger Manufacturing division of the Central Alloy Steel Corporation.

Fred C. Conners having resigned as secretary, assistant treasurer and director of **A. M. Castle & Co.**, Chicago, effective March 19, the board of directors have elected **Leonard J. Quetsch**, secretary and director to succeed Mr. Conners.

The Hopkins-Benedict Company, Railway Exchange Building, Chicago, Illinois have been appointed representatives for the Chicago district for the Snapon Anchor manufactured by the **Anchor Company** of Milwaukee, Wis.

Bentley & Holmgren, Court Exchange Building, Bridgeport, Conn., have been appointed representatives for Connecticut and western Massachusetts for the **Foote Bros. Gear & Machine Co.**

Leeds, Tozzer & Co., Inc., 75 West street, New York, N. Y. have just been appointed as distributors to the railroad field of the well known line of Stuebing-Cowan hand and electric lift trucks, and Steel-Round platforms.

The Larkin Company, 6200 Maple avenue, St. Louis, Mo., announces the outright purchase of all the property and entire assets of the **Davis Boring Tool Co., Inc.**, including the two-story building they now occupy at 3693 Forest Park Blvd.

Frank K. Tutt has become a district manager of the **Bird-Archer Co.**, at St. Louis, Mo., office in Railway Exchange Building.

W. S. Peddie, comptroller of the **Minneapolis Steel & Machinery Company**, Minneapolis, Minn., has also been appointed treasurer to succeed **E. A. Merrill**, retired.

E. S. Berry has been appointed resident manager of the Canadian district of the **Union Switch & Signal Company**, with headquarters in the Transportation Building, Montreal, Que., to succeed **Paul Kircher**, deceased.

The Standard Steel Car Co. has purchased the **Illinois Car & Mfg. Co.**, Chicago. **P. H. Joyce** has been made vice-president of the former company.

Charles W. Beaver of Stanford, Conn., formerly sales manger of the **Yale & Towne Manufacturing Company**, has been elected president, treasurer and general manager of the **Lockwood Manufacturing Company**, South Norwalk, Conn.

The Worthington Pump & Machinery Corporation executive officers, export sales department and New York district sales department, will be removed from 115 Broadway to 2 Park Avenue, New York City.

Myron F. Westover, secretary of the **General Electric Company** for the past 34 years, retired on March 1, and **William W. Trench**, assistant secretary, has been elected by the Board of directors to succeed him.

E. M. Converse has recently been appointed Sales Manager of the **Dearborn Chemical Company.** He relieves **W. A. Converse**, Secretary and Chemical Director, who has served as Director of Sales in the Stationery Department for many years, and who will now devote more of his attention to matters of general company operation.

E. M. Converse started as a laboratory assistant in 1902. He was trained in chemistry and chemical engineering at Armour Institute and Northwestern University.

In 1906 he was given charge of inspection of materials. In 1908 and until 1918 he was on the road in the capacity of a sales and service man. He was then appointed manager of the Specialties Department of the Company, devoted, among other items, to the development of and introduction of NO-OX-ID Rust Preventive to manufacturers of steel products and users of steel equipment, obtaining during this period since 1918 international distribution and use of NO-OX-ID in many industries. In assuming his new duties, the two departments will be merged and Mr. Converse will be Sales Manager for both departments.

A. L. Roberts, formerly of the **Central Alloy Steel Corporation**, Massillon, Ohio, has joined the development and research department of the **International Nickel Company**, New York.

Items of Personal Interest

G. E. McCoy, superintendent of car equipment, Atlantic Region of the Canadian National Railway has been appointed general superintendent car equipment, Atlantic Region with headquarters at Moncton, N. B.

F. J. Baird, formerly shop foreman of the Canadian Pacific Railway, Vancouver, B. C. has been appointed gang foreman, Ogden, Calgary, Alta., succeeding **A. H. Alexander**,• granted indefinite leae of absence on account of illness.

A. M. Kelly has been appointed airbrake instructor, Western Lines of the Canadian Pacific Railway, Winnipeg, Man., succeeding **A. H. Cuthbert**, appointed general airbrake instructor.

B. P. Johnson has been appointed mechanical superintendent of the Northern Pacific Railway Eastern Lines, headquarters St. Paul, Minn., succeeding **T. J. Cutler**, retired on pension and **G. F. Egbers** becomes general master mechanic at Livingston, Mont.; **R. P. Blake** has been made master mechanic at Spokane, Wash., and **J. B. Neish** becomes master mechanic at St. Paul.

R. W. Wray has been appointed superintendent of motive power of the Pennsylvania Railway, Lake Division, with headquarters at Cleveland, Ohio, succeeding **W. Y. Cherry** transferred to similar position on the Long Island Railroad, at Richmond Hill, N. Y.

W. A. Curley has been appointed master mechanic of the Missouri Pacific Railroad at McGehee, Ark. Other appointments on this railroad are as follows: **F. W. Burch**, general shop foreman at Gale, Ill.; **H. J. Wade**, road foreman of engines at Kansas City, succeeding **N. Nissen**, who has been transferred to Falls City, Neb.; **E. J. Crawford**, machine shop foreman at Kansas City, Mo.; **B. E. Piggott**, roundhouse foreman at Wichita, Kansas, and **W. A. Farris**, roundhouse foreman at Kingville, Tex.

T. F. Howley has been appointed supervisor of fuel and locomotive operation of the Erie, office at New York City, and **James Cunneen** has been made road foreman and fuel supervisor at Hornell, N. Y., and **John A. Cooper**, at Meadville, Pa.

G. B. Hauser, motive power inspector at the Meadows shop of the Pennsylvania Railroad, has been transferred to the office of Superintendent Motive Power, New York.

J. D. Cousins has been made road foreman of engines of the Long Island Railroad with headquarters at Jamaica, N. Y., succeeding **J. B. Ward** retired.

W. R. Elsey, Assistant master mechanic on the Pennsylvania Railroad at Conemaugh, Pa., has been appointed master mechanic at Baltimore, Md., succeeding **J. Young, Jr.**, who has been transferred to Renovo, Pa.

W. C. Sherman, road foreman of engines on the Atchison, Topeka & Santa Fe Railway, has been transferred from Canadian, Tex., to La Junta, Colo., succeeding **L. W. Gilbert**, deceased. **E. A. Shields** becomes road foreman at Canadian, and **A. H. Allison** becomes fuel supervisor at La Junta succeeding Mr. Shields.

H. J. W. Kleine, assistant road foreman of engines of the Pennsylvania Railroad at Philadelphia, has been appointed assistant master mechanic at Conemaugh, Pa.

E. J. Cyr, formerly assistant master mechanic of the Chicago, Burlington and Quincy Railroad at Galesburg, Ill., has been appointed assistant master mechanic on the Chicago and Aurora divisions, with headquarters at Aurora, Ill., the office of master mechanic at Aurora has been abolished. **W. A. Kelly**, master mechanic at Ottumwa, Iowa, has been appointed assistant master mechanic with jurisdiction over **West Ottumwa.**

H. C. Fuller, engineman, Toledo Division of the Pennsylvania Railroad was promoted to position of assistant road foreman of engines, Fort Wayne division, succeeding **A. C. Beredelman**, promoted to position of road foreman of engines on the Indianapolis Division.

Obituary

John R. Kenly, president of the Atlantic Coast Line, died at his home in Wilmington, on March 1st at the age of 81 years, and had spent 60 years in railroad service. He was born in Baltimore, Md., on January 21, 1847. His first position was with the engineering department of the Baltimore & Ohio Railroad in 1868, and later became resident engineer of the road. In 1882 he was made superintendent of the old Richmond & Petersburg, thus beginning the connection with the Altantic Coast Line which ended in his presidency of the line. He was made superintendent of transportation of the Atlantic Coast Line in 1885 and successively: assistant general manager in 1889; general manager in 1891; fourth vice-president in 1902; third vice-president in 1905 and president on December 8th, 1913.

F. P. Pelter, vice-president and general manager of the Norfolk Southern, died at his home in Norfolk on February 18th.

W. A. Gore, for a number of years past general manager of the Virginian Railway, and who retired from active service some months ago on account of ill health, died at his home in Norfolk, Va., on February 24th.

New Publications

Books, Bulletins, Catalogues, Etc.

Directory of Freight Service of the Pennsylvania Railroad. For the information and convenience of shippers and consignees, the Pennsylvania Railroad has prepared and is issuing in pamphlet form a full compilation of the through package freight cars operated between principal points on its lines and to stations on connecting railroads. The new pamphlet gives in its 53 pages complete information concerning the point of origin and destination of each package car, forming a comprehensive service manual for the guidance of shippers and receivers of freight. It is the first publication of its kind ever issued by any railroad. A special feature of the pamphlet is condensed information concerning the Company's scheduled, limited freight trains. The name, point of origin, destination and schedule of each of these trains is given, together with the commodities it carries. Several pages also are devoted to other through, fast freight train service which is regularly scheduled, but to which no special train names have been assigned. As a large majority of the through package cars move in this freight train service, the pamphlet represents practically a complete directory of the Pennsylvania Railroad's preference freight operations.

A list of 38 points on the system, at which reports are compiled daily of passing freight cars, is also printed in the pamphlet for the convenience of patrons. These passing reports are prepared for the purposes of assisting shippers and consignees in tracing their cars.

The new directory of freight service has been prepared and is being distributed by the Freight Traffic Managers of the three operating regions of the Pennsylvania Railroad, and will be furnished upon request by any representative of the Freight Traffic Department.

The Value of Acetylene and City Gas as Fuels for Cutting Iron and Steel With Oxygen is the subject of the booklet now being distributed to interested engineers by the International Acetylene Association.

This subject is considered both from the standpoints of theory and practice. In one comprehensive study by J. K. Mabbs of the Union Carbide Sales Company, New York, the laboratory aspects of this question are discussed in detail. J. L. Anderson, National Carbide Company, New York, discusses the matter from the standpoint of the shop man, basing his conclusions upon the experience of a large number of concerns who have tried both acetylene and city gas as cutting fuels over appreciable periods of time on commercial cutting operations.

The data contained in this booklet should be of inestimable value to engineers, plant managers and others who desire real information on the subject and who may be considering the efficiency of one gas or the other as a cutting medium. Copies can be obtained by addressing the office of the Secretary, International Acetylene Association, 30 East 42nd Street, New York City.

"Elescooperation." A sixteen page booklet under the foregoing title has been issued by the Superheater Company, 17 East 42nd St., New York, outlining the organization and engineering service of the company. It describes the Elesco stationary power plant superheater and the progress in Elesco served power plants. A chart shows the expected performance of the superheaters at the Hell Gate and East River stations of the United Electric Light & Power Company and the New York Edison Company.

Locomotive Chart. The Locomotive Publishing Co., Ltd., London, England, has recently published a chart showing the details of the locomotive "Lord Nelson" of the Southern Railway of England. This is included in a booklet, the cover in color. The text includes particulars of the engine, while the chart is in section, suitably colored and lettered, with reference to a table of parts, to render the main features of construction clearly apparent. Plan and sectional drawings are also reproduced.

"What Results" is the title of a twenty page booklet recently issued by the Locomotive Firebox Company, Chicago, Ill., containing the service reports in regard to locomotives equipped with the Nicholson Thermic Siphons, some of which have now been in service over ten years. Some of the leading railways are using Siphons in new and old locomotives in the interest of safety, increased capacity and economy. All of these claims seem to be thoroughly established for Siphon equipped engines from the extracts from officials and typical service reports which are published in the booklet.

Copies may be had on application to the Locomotive Firebox Company.

Statistics of Railways in the United States. The Bureau of Statistics of the Interstate Commerce Commission prepared and has issued their fortieth annual report on the statistics of Railways of the United States for the year ending December 31, 1926. In it is also included selected data on carriers by water, the Pullman Company, electric railways, telegraph and cable companies, pipe line and telephone companies. It contains 138 pages and copies may be had from the United States Government Printing Office, Washington, D. C., sending the price 25 cents.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

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Locomotive Terminal Improvement of the New York Central

Modern Engine House at Harmon, New York Now in Service

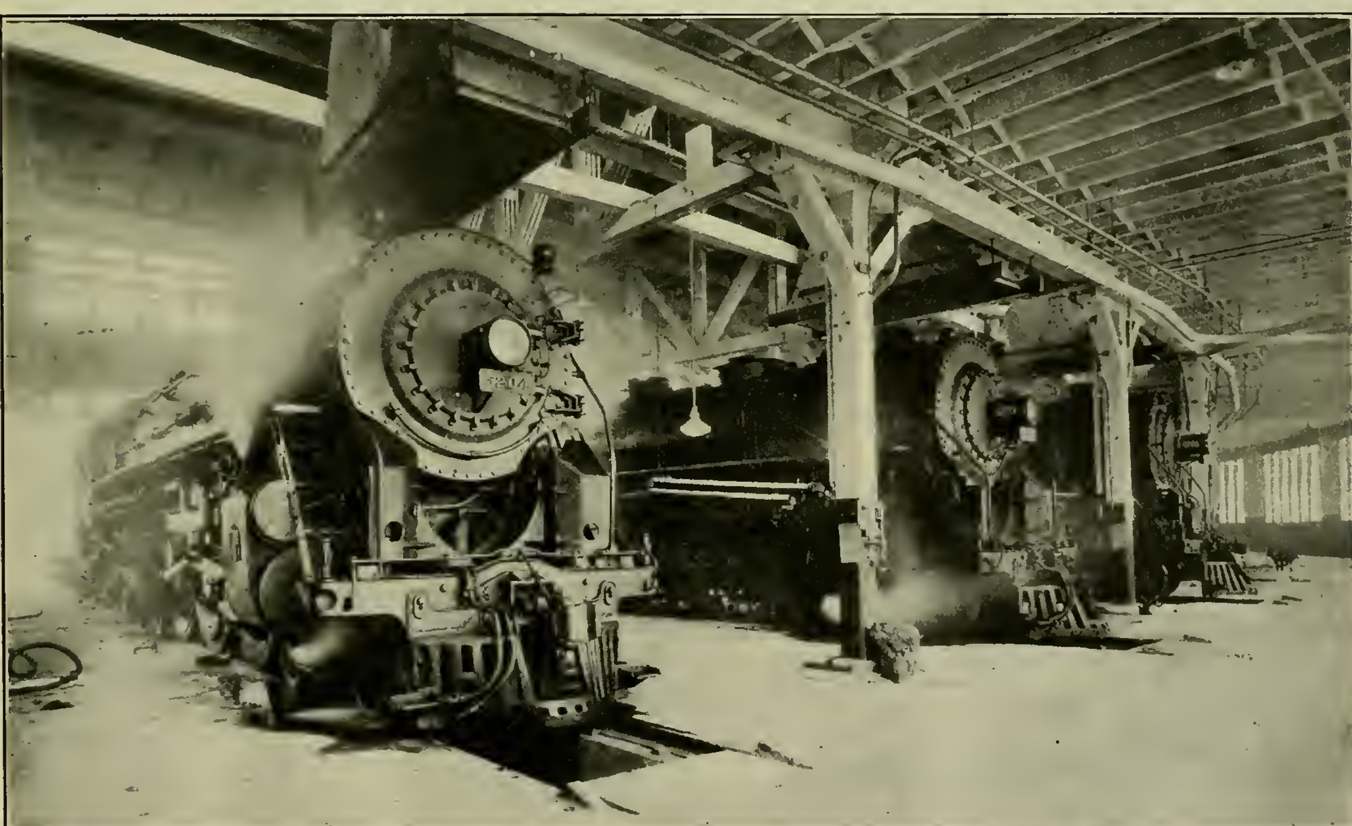
The New York Central Lines' new locomotive terminal improvement at Harmon, N. Y., including a modern engine house, ranks as one of the largest in the Metropolitan District and is now in service.

This added facility for housing locomotives at this important division point, where the New York Central changes from electric to steam power, is the first of a number of improvements being carried out at Harmon to keep pace with the road's constantly increasing traffic and additions to equipment.

Work on this project was begun in April, 1927, and included the removal of a sand hill requiring the handling of 500,000 cubic yards of material, the larger part of which was taken to Croton, N. Y., and used for fill in the freight yard development at that point.

The new engine house, which was the center of the improvement, was started on July 1, 1927. It is located west of the old round house and is a one-and-a-half story brick structure of the customary semi-circular shape. It is equipped with thirty-one stalls as compared with twenty-five stalls in the old house, and which continues to remain in use.

One of the features of the new building is its depth, which provides 120-foot depth for twenty-five storage stalls and 150-foot depth for the drop-pit section housing six locomotives.



Interior View of New York Central's Engine House at Harmon, N. Y.

The 120-foot depth of the storage tracks and 150-foot depth of the drop-pit tracks was necessitated by the increased individual size of the sixty Hudson type passenger locomotives which the New York Central recently put in service. These locomotives with tender, are ninety-five feet eleven inches overall, and were longer than the track space provided in the old roundhouse.

The construction of the engine house involved many complicated engineering problems. In the first place, the area of some two acres used for the terminal, was in past years formerly a part of the Hudson River bed. Some of this river bed had been filled in by erosion and deposits by the river and some of it had been filled in by artificial means. The borings taken over this area showed a five-foot layer of soft river mud from twenty to thirty feet below the surface, which necessitated the construction of a foundation for the enginehouse which would extend into the underlying gravel formation. To accomplish this the structure has been built on more than one thousand concrete piles.

The driving of these piles was in itself a noteworthy engineering achievement. As worked out by New York Central engineers and the contractors, steel castings to cover the full length of the pile were first driven and filled with concrete. As soon as the concrete was sufficiently set the castings were lifted and driven at other points.

With this foundation completed, the westerly portion of the main building including engine storage pits of reinforced concrete were carried directly on these piles. The foundation for the drop-pits in the easterly end was built in quick-sand formation, so no piles were used. The bottom of the pits is below the level of the river.

The 120-foot stall section of the engine house provides ample room for the largest steam motive power of the present. The six 150-foot stalls in the drop-pit section have been provided with drop-pit electric jacks, tables, and wheel service tracks which enable this terminal to change driving wheels, pony trucks and tender trucks for locomotives requiring such replacements. This particular facility will reflect important operating economies in the handling of locomotives at this terminal.

The drop-pit section has a driver pit with one fifty-ton traveling jack and two elevator platforms, a truck and pony pit with similar equipment and a tender pit with a 30-ton traveling jack and the elevator platforms.

All the jacks are of the four-screw type mounted on four-wheel carriages and operated electrically. Each one serves two engine pit tracks and one wheel service track.

One of the outstanding features of the traveling electric jack is its control by engine house mechanics through the use of a portable electric push button switch box.

The superstructure of the engine house building consists of brick walls and timber roof truss construction. The customary monitor roof is supported by sixty-foot trusses in the twenty-five stall section and seventy-two-foot trusses in the 150-foot section. Square type smokestacks are used throughout the house to care for the smoke and steam exhausts. In the monitor section twenty-four-inch ventilators are installed, with eighteen-inch ventilators in the head-room section circling the house. To the north of the engine house is a separate two story building eighty-five by ninety feet, in which are located the heating apparatus for the engine house, boiler washing plant, pumps and electric substation together with lockers and toilet facilities for employes. In this building, all the equipment is the latest type and includes tanks for boiler washout, filling and blowing off of locomotives, stack blowers, and cold water service lines. The boiler washing system has three 50,000-gallon steel tanks in this building, one used for filling water, one for washout water and one a reserve unit. The washout pumps in this plant are reciprocating type steam pumps, 1,000 gallon per minute capacity.

New 100 Foot Turntable of the New York Central Lines at Harmon, N. Y.

The heating unit in this annex building is of the hot air type. It is equipped with a fan eighty inches in diameter, driven by a reciprocating steam engine. Hot air is driven through an underground main duct to the engine pits. Electric power for the new house is carried from the present powerhouse switchboard to the outdoor substation and substation in the annex building. The former is used for the operation of the turntable and the latter for engine house requirements. The electric equipment also includes electric flood-lights to illuminate the ash pits, locomotive yard and turntable equivalent practically to a twenty-four-hour daylight operation.

The new 100-foot turntable which is one of the features of the new locomotive terminal is of the continuous type driven at either end by two thirty-horsepower electric motors with an auxiliary gasoline engine drive on one end. Piling was omitted from the turntable foundations and all the footings were spread for a loading of one ton per square foot on the terrain. Included in this new terminal are two circular ash-pits each thirty-two feet inside diameter and twenty feet deep and correlated with the two inbound engine house tracks. The capacity of each pit is about 160 cubic yards which provides considerable storage and does not require daily digging out. These pits are cleaned with a locomotive crane using a clamshell bucket, and a track has been laid for ash-pit cleaning operations. The new terminal has an extensive track layout which provides two inbound and two outbound tracks, the ash-pit storage trackage and connections to the old round house, which will be continued in use, and other existing track facilities.

Included in this new development is the provision made for water service for the enginehouse and fire protection system, secured by the installation of an 800,000-gallon steel stand-pipe used for service purposes and fire reserve and a 20,000-gallon tank used for the ash-pit water supply.

High Marks of Efficiency in Railway Freight Operation

By W. E. Symons

In response to numerous comments and inquiries pertaining to the article in our March issue under the caption of "The Past and Future in Railway Efficiency," such additional data as seems to the writer as pertinent to the subject is embodied in the present article.

An effort is here made to draw in tabulated form a picture which, if studied alone, or in connection with the previous article, will throw light on what has been accomplished and indicate the direction in which still greater economies may be effected. In the former article no reference was made to volume of traffic moved except as it may have been inferred from the average tons per train. This is a very indefinite measure as the individual train loads might be high and the gross ton per miles per day comparatively low. In order to show the relation between these factors the present tabulation shows not only the gross and net tons of freight moved per mile of road per day, but other items that are of value in considering the various angles of that matter.

It will be observed that the gross tons per mile per day varies from 7,454 to as high as 34,531, and although the Chesapeake & Ohio with the maximum gross per day only receives $1.756 for each ton of freight handled and a rate per ton mile of only about six mills (.00602), yet they get a haul of 291.7 miles per ton with an average of 1,414 tons per train, and finally the crux to economy in train movement is the fact that they only consume 101 lbs. of coal per 1,000 gross ton miles at a cost of 8.6 cents.

Of course, the price per ton of coal is a controlling factor in the items of cost of train movement. It will be observed that of the 40 lines there are five that pay less than $2 per ton for coal and seventeen that pay less than $2.50 per ton. Some of the latter have a cost of 20 to 22 cents per 1,000 ton miles for the item of fuel. It must be clear that the C. & O. line with its mountainous grades have actually accomplished something in the matter of economy in train operation that can well be studied along with other features.

A spread or variation in the price of fuel ranging from about 8.5 mills to as high as two and two-tenth cents per lb. and a range in the quantity used from 90 to 195 lbs. per 1,000 gross ton miles of freight moved, not only gives a

Railway Facilities and Comparative Results from Their Operation

		Mileage, Earnings, Traffic, Revenue and Length of Haul								Engines, Unit Costs and Operating Results									
	1926 Name of Railway	Miles of Road	Earnings Per Mile	Gross Ton Miles Per Mile Per Day	Net Ton Miles Per Mile Per Day	Aver. Tons Per Train	Rev. Per Ton Freight	Rev. Per Ton Mile	Aver. Haul Per Ton	Number Engines	Average Tractive Power	Annual Cost of Repairs	Cost Per Mile Run	Cost Per 1,000 Lbs. T. Power	Lbs. Coal Per 1,000 Ton Miles	Cost Coal Per Ton	Cost Coal Per 1,000 Ton Miles	Operating Ratio Per Cent
1	At. Coast Line...	4,996	$19,689	8,461	3,237	566	$2.516	.01431	175.8	938	32,750	$6,337	.227	$193	122	$3.26	19.9	72.8
2	A. T. & S. Fe..	10,275	22,088	10,519	3,939	690	4.004	.01275	314.0	1,737	46,085	7,831	.251	170	119	4.49	26.6	64.3
3	B. & O..........	5,288	47,690	21,123	11,747	918	1.860	.00993	187.3	2,469	49,496	8,794	.305	177	166	1.81	15.0	73.8
4	Bess. & L. E....	228	74,429	31,231	29,046	1,667	776	.00717	108.2	173	46,416	6,981	.382	150	119	2.42	12.2	58.1
5	Boston & Maine..	2,111	37,350	8,706	3,977	544	2,149	.01706	126.0	933	30,424	6,589	.301	216	140	4.57	32.0	76.4
6	Cent. of N. J....	691	86,507	17,794	11,708	895	1.113	.01610	69.1	567	36,776	6,842	.293	187	163	3.55	28.9	76.4
7	Chicago G. W....	1,496	16,951	11,423	4,139	665	2.794	.00959	291.4	272	39,589	7,325	.235	185	139	3.10	21.5	79.0
8	C. M. & S. P....	11,201	14,342	7,844	3,324	712	2.539	.01039	244.5	2,004	37,932	5,812	.227	153	141	2.51	17.7	80.0
9	C. B. & Q.......	9,392	17,156	9,562	4,332	794	2.763	.00960	288.0	1,944	37,762	5,540	.219	147	140	2.55	17.9	72.2
10	C. & N. W......	8,461	18,245	8,467	3,407	580	1,869	.01269	147.3	1,996	35,514	6,372	.261	179	138	2.38	16.4	78.1
11	C. R. I. & P.....	8,020	17,188	8,931	3,282	553	3,025	.01229	246.2	1,555	37,013	8,675	.255	234	147	2.97	21.8	74.5
12	C. & O..........	2,651	50,627	34,531	21,713	1,414	1,756	.00602	291.7	1,041	53,494	10,356	.359	193	101	1.71	8.6	67.9
13	Del. & Hud......	882	52,585	19,226	12,447	886	1.494	.01061	140.8	461	43,182	8,994	.347	209	156	2.66	20.7	75.1
14	D. L. & W......	990	89,991	22,939	14,772	784	2.234	.01313	170.2	751	39,007	7,477	.266	190	153	3.24	24.6	70.2
15	D. & R. G.......	2,562	13,278	5,577	2,347	709	3,430	.01654	207.4	489	41,425	5,309	.257	128	195	2.29	22.3	72.7
16	D. T. & Iron....	486	26,476	13,321	6.171	674	1,378	.01415	97.4	84	37,545	17,504	.552	466	111	3.37	19.7	68.2
17	Erie	2,446	54,065	22,060	13,725	965	2,185	.00980	222.9	1,223	46,903	7,349	.346	156	128	2.95	18.8	79.0
18	Great Nor.	8,164	14,336	7,454	3,344	980	2.658	.01048	253.5	1,306	44,098	4,418	.207	100	128	3.88	24.8	64.1
19	Hocking Val.	349	56,087	29,430	21,042	1,607	742	.00655	113.4	136	50,207	9,232	.234	184	124	1.85	11.5	70.7
20	Ill. Cent.	6,585	28,798	16,526	7,472	754	2.342	.00925	253.2	1,962	41,363	7,712	.238	186	133	2.25	15.0	76.8
21	L. & N..........	5,034	22,322	16,755	7,810	656	1.841	.00877	209.9	1,359	39,363	9,369	.256	238	163	1.85	10.8	76.4
22	Lehigh Val.	1,364	58,994	19,730	12,097	822	2.088	.01156	180.6	927	42,991	7,763	.258	180	153	3.45	26.4	75.8
23	Mich. Cent.	1,856	51,468	15,788	6,953	662	1.944	.01424	136.4	716	40,277	7,390	.236	184	117	3.78	22.1	68.0
24	Mo. Pac.	7,348	18,237	11,172	4,450	717	2.584	.01065	242.6	1,227	39,510	8,764	.273	221	129	2.78	17.8	76.8
25	Nor. Pac.	6,682	14,568	7,655	3,334	789	3.316	.01148	288.9	1,242	39,829	3,963	.186	97	142	3.16	22.4	70.1
26	New York Cent..	6,928	57,669	16,890	10,560	926	2,109	.01051	200.7	3,664	44,084	7,393	.259	185	124	2.68	16.6	74.8
27	Nor. & West.....	2,241	53,719	34,480	21,685	1,572	1.868	.00650	287.3	941	57,601	9,948	.403	172	142	1.75	12.2	59.2
28	N. Y. C. & St. L.	1,692	32,478	22,744	8,725	672	2.205	.01014	217.4	502	38,435	6,914	.220	180	115	3.14	18.1	72.8
29	New Haven	1,912	70,457	9,291	5,092	588	2.336	.02071	112.8	1,007	35,986	9,043	.346	251	128	4.43	28.4	73.7
30	Pere Mar	2,286	20,385	9,642	4,045	604	2.009	.01211	165.9	448	34,997	6,094	.224	174	115	3.45	19.8	69.6
31	Penn. System....	10,906	66,271	21,535	13,462	897	2.056	.01024	200.7	7,001	48,000	8,797	.308	183	136	2.10	14.2	77.6
32	Phila. & Read....	1,140	86,517	24.524	18,366	943	1.187	.01165	101.9	775	41,548	6,118	.232	147	160	3.02	24.2	74.0
33	Pitts. & L. E....	231	147,784	25,575	29,493	1,500	729	.01195	61.0	292	46,451	5,626	.253	121	90	2.30	10.3	80.5
34	Seaboard	4,033	16,997	8,280	2,933	592	2.330	.01343	173.5	709	38,864	5,788	.197	149	139	3.04	21.3	73.5
35	So. Pac. P. S....	8,929	23,706	[illegible]275	4,056	693	3.492	.01389	251.3	1,750	41,931	6,975	.225	166	128	4.49	28.7	68.4
36	Southern	8,140	24,966	[illegible]801	4,926	559	2,580	.01177	219.2	2,262	42,355	6,676	.247	157	159	2.13	16.9	69.2
37	Tex.-Pacific	1,954	18,146	[illegible]898	2,955	579	2.606	.01442	180.8	334	40,251	8,322	.312	208	111	4.50	25.0	74.7
38	Union Pacific....	3,714	30,832	[illegible],429	7,194	795	4.658	.01078	432.0	876	48,068	9,332	.293	194	115	2.85	16.4	65.0
39	Wabash	2,524	28,402	15,498	6,655	683	2,630	.01064	247.1	689	39,724	7,335	.248	184	131	2.30	15.0	73.2
40	Wbeeling & L. E.	512	40,903	18,392	9,382	1,024	1.013	.01138	89.1	200	47,251	7,756	.378	165	163	1.98	16.1	71.6
	Total or averages.....	166,700	41.067	16,037	9,233	840	2,717	.01163	198.6	48,992	41,862	7,620	.280	184	123	2.92	19.5	72.4
	Total or averages, U. S.	.....	36,907	......	......	772	.....	......	.....	.....	.....	.....	....	...	137	2.63	....	....

W. E. Symons. May, 1928.

fair idea of the room there is for much greater economy in its use, but of the arbitrary effect of its cost or purchase price on total costs of train operation.

The average ton per train, the revenue received per ton of freight handled, the revenue per ton mile and the length of haul are all factors that have bearing on or affect to a great extent the prosperity of a carrier. These are all shown in the tabulation for comparison and study.

It will be noted that the amount received for each ton of freight handled varies from .729 cents to as high as $4.65, while the revenue per ton miles varies from (.00602) about 6 mills to as high as (.02071), slightly more than 2 cents per ton mile. The length of the freight haul ranges from a low of 61 miles to as high as 432 miles. All of which shows the varying wide fluctuation in the controlling factors of transportation.

In the tabulation a new "yardstick" has been introduced as to the relative cost of repairs to locomotives which has for its basis the capacity or size of the engines as measured by the average tractive power of the equipment on each line.

It will be observed that the average tractive power varies from 30,424 to as high as 57,601 lbs. The annual cost of repairs per unit ranges from a low of $3,963 to a high of $17,504, while the cost per mile run varies from 18.6 to as high as 55.2 cents.

Another new figure introduced is the cost per 1,000 lbs. of tractive power based on the average size of all engines in use on the respective lines. While it is in reality no less arbitrary than other measures now used, in that all others assume uniformity of size, physical condition, age, etc., it has the advantage of a differentiation in relative size of the power as between different lines.

It will be observed that the annual cost of repairs per 1,000 lbs. of tractive power ranges from a low of $97 to as high as $466. While some may feel that the cost of $97 is not sufficiently liberal to properly maintain power, yet it must be borne in mind that under certain conditions, power with this expenditure might be in much better condition than on other lines in similar territory where the expenditure per unit, per mile, and per 1,000 lbs. tractive power was much greater.

The cost of repairs is the amount put back into each unit, and the equipment as a whole, and should be exactly what service has taken out of its condition or value. That and no more or less should be a correct maintenance charge. Measured by this standard, no one with an elementary knowledge of these problems will hestitate to say that a unit cost per annum of $17.504, a mile run cost of 55.2 cents, and a cost of $466.06 per 1,000 lbs. of tractive power is simply out of the question, as under no operating conditions can service take such a toll from locomotives.

It is fair to assume that much of the above mentioned abnormal costs and cited with respect to the D. T. & I., either belongs to arrears of former years, or should be charged to capital account as improvements and additions or betterments and are not properly an operating expense.

Admittedly, there can be no definite arbitrary standard or yardstick by which to measure all or any one of these factors or items of expense on the railways of this country. Yet, it is the belief of the writer that a study of these various factors by those who are interested in obtaining a higher degree of economy in operation by the comparison of the results obtained on the different lines, cannot fail to be helpful. To those so interested, the foregoing tabulation and comments are submitted.

It is our belief that a careful study of the old or conventional units of costs as well as the new measures added will prove the reasonableness of unit costs in reaching conclusions.

Railroads' Safety Record Best in History

The railroads, during the past eight years, have made the greatest progress in increasing safety of rail transportation ever attained by the carriers of this country, culminating in the year 1927 in the best safety record ever established by them, R. H. Aishton, Chairman, Executive Committee of the Association of Railway Executives, told the Interstate Commerce Commission in asking that body to permit the managements free opportunity to exercise their judgment in determining in what direction expenditures can best be made to insure the greatest possible safety for employes and the public and generally increase safety in train operation.

Despite the hundreds of millions of persons who ride on the railroads each year, only ten were killed in train accidents in 1927, a new low record for any one year and a decrease of 69 under 1926. An improvement in safety among employes was also reported in 1927.

Mr. Aishton told the Commission that in the past eight years the railroads have expended $323,701,000 of new capital for safety purposes. Of this amount, all except $22,395,000 has been expended voluntarily by the individual managements and without orders from the Commission for various safety devices such as automatic and other signals, for inter-locking plants, crossing signals, highway grade separation, and for the extension of automatic train control beyond the two orders that have already been issued by the Commission. Mr. Aishton explained that the $22,395,000 mentioned above represented the cost of automatic train control devices installed by the various railroads in response to the orders of the Commission.

"This statement of capital expenditures," he continued, "is limited to the period, January 1, 1920, to January 1, 1928, and, therefore does not take into consideration similar capital expenditures for installations prior to 1920. The figures so far presented take account only of the capital cost of physical installations, and have no reference to annual charges for operation, maintenance, and retirements. Annual expenditures for the items enumerated above, including the operation, maintenance and retirements of safety appliances installed prior to 1920 as well as those installed since 1920 are estimated at $89,-663,000 for the year 1927.

Combating the Crossing Evil

"The duty of the railroads is not confined alone to that portion of the public using its rails. There is also a direct responsibility to that portion of the public who are subject to hazards incident to train or engine operation at grade crossings. In the past eight years mileage of improved highway has increased 34.3 per cent in the United States while there has been an increase of more than 150 per cent in the number of automobiles in operation. The number of highway grade crossings has increased 7,858 or 3.5 per cent. Fatalities as a result of highway grade crossing accidents in 1927 totaled 2,371 or an increase of 32.4 per cent compared with the number in 1920.

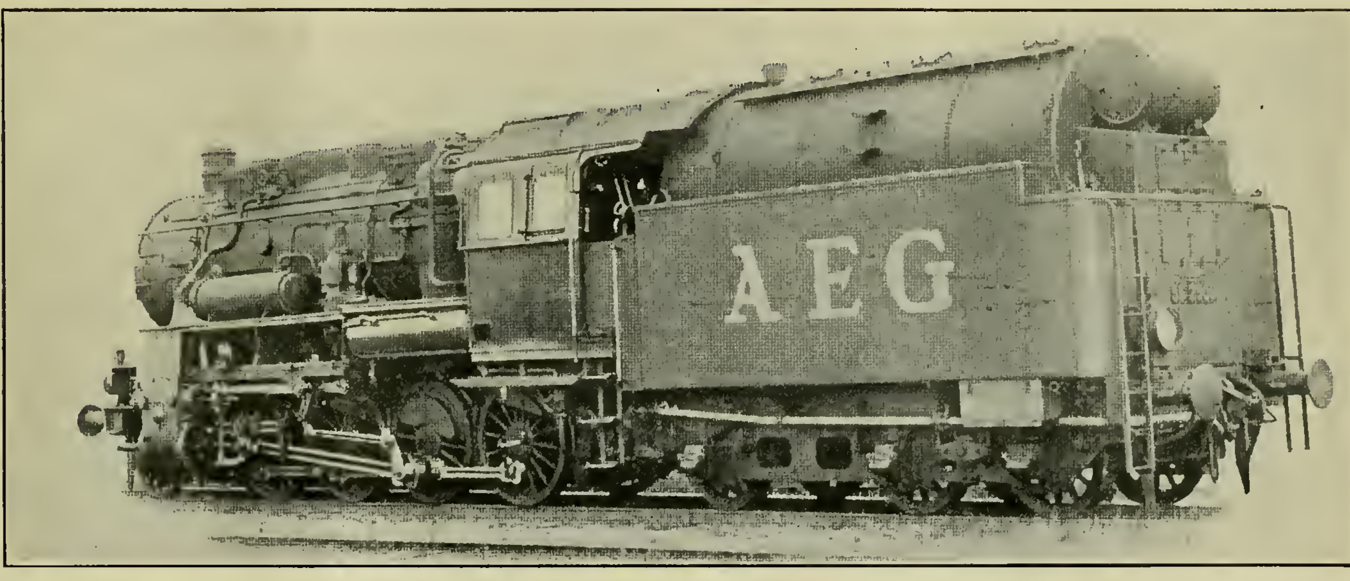
"The Association of Railway Executives unanimously recommends that the issuance of any additional formal orders which require the installation of automatic train control, or of other forms of safety appliances, be withheld at this time, so as to afford to the management of the railroads of this country a free opportunity to determine, from their direct and intimate knowledge of individual operating conditions and with full recognition of their responsibility in progressive safety work, in what direction expenditures can be made that will attain the highest degree of safety for employes and the public and generally increase safety in train operation."

A New Design of Pulverized Fuel Burning Locomotive

Tests on German Railways Show Satisfactory Results

While there have been several designs of pulverized coal burning locomotives built, and experiments have been conducted in this and other countries, virtually all of these have been abandoned, but there is in service on the Kansas City Southern Railway another experimental locomotive that is equipped with a unit pulverized coal stoker. Data is not yet available on the performance of this engine. On account of the limited amount of space available, the locomotive firebox has presented difficulties in developing a satisfactory arrangement for a pulverized fuel burning engine.

The Allgemeine Elektricitäts-Gesellschaft, Hennigsdorf, of Berlin, Germany has recently turned out a design of pulverized fuel burning locomotive that is giving satisfactory results on the German Railways. In 1924 the Company began experiments with pulverized fuel using a standard boiler such as is used on the freight train locomotives on the German Railways. The boiler by the autumn of 1926 had given sufficiently satisfactory results to warrant the working out of a design for a pulverized-fuel locomotive. The test showed an increase of boiler efficiency from 52 per cent with normal firing to 67.5 per cent with pulverized fuel, and with an hourly load on the heating surface of 70 kg. per square meter of surface. Difficulties associated with combustion and the production of slag were overcome by selecting convenient nozzles for subdividing the pulverized fuel. Particularly satisfactory results were obtained in connection with pulverized lignite, to the use of which the German Railways Company attached particular importance.



New Pulverized Fuel Burning Locomotive in Service on the German Railways

The tender of the locomotive, as shown by the accompanying illustration, was specially equipped for carrying and feeding the pulverized fuel to the firebox. The fuel bunker resembles a lengthy cylinder masuring about 6 ft. 6¾ in. diameter by about 13 ft. in length. Its capacity is 12 cu. meters (423.7992 cu. ft.), sufficient for accommodating 6 tons of lignite. The two conveying screws supplying the pulverized fuel to the locomotive nozzles are capable of dealing with a maximum of 2,100 kg. per hour at a maximum rate of 140 r.p.m., the amount of pulverized fuel actually supplied being controlled by the number of revolutions made by the conveying screws A blower supplying the primary air is driven by a simple steam turbine and paddled wheel, its maximum output being 7 H.P. It was compulsory to adopt this turbine on account of the very high speed in revolutions required by the blower, which speed reached as high as 4,500 r.p.m.

A small steam engine is used to drive the slowly-rotating conveying screws, and this at a pressure of 5 atmosphere drives the two screws, using from 30 to 50 kg. (66.138 to 110.23 lb.) of steam per hour. A small auxiliary burner at the rear wall of the ash pan serves as an igniter while the locomotive is stationary or when coasting, and is intended to make up for the radiation losses of the boiler, and supplying steam for the air pump, so that the main burner need not be called upon in such conditions. The auxiliary burner derives its air from a small blower driven by the steam engine. The tender equipped with pulverized coal weighs about 3.8 tons more than the standard locomotive tender of the same class.

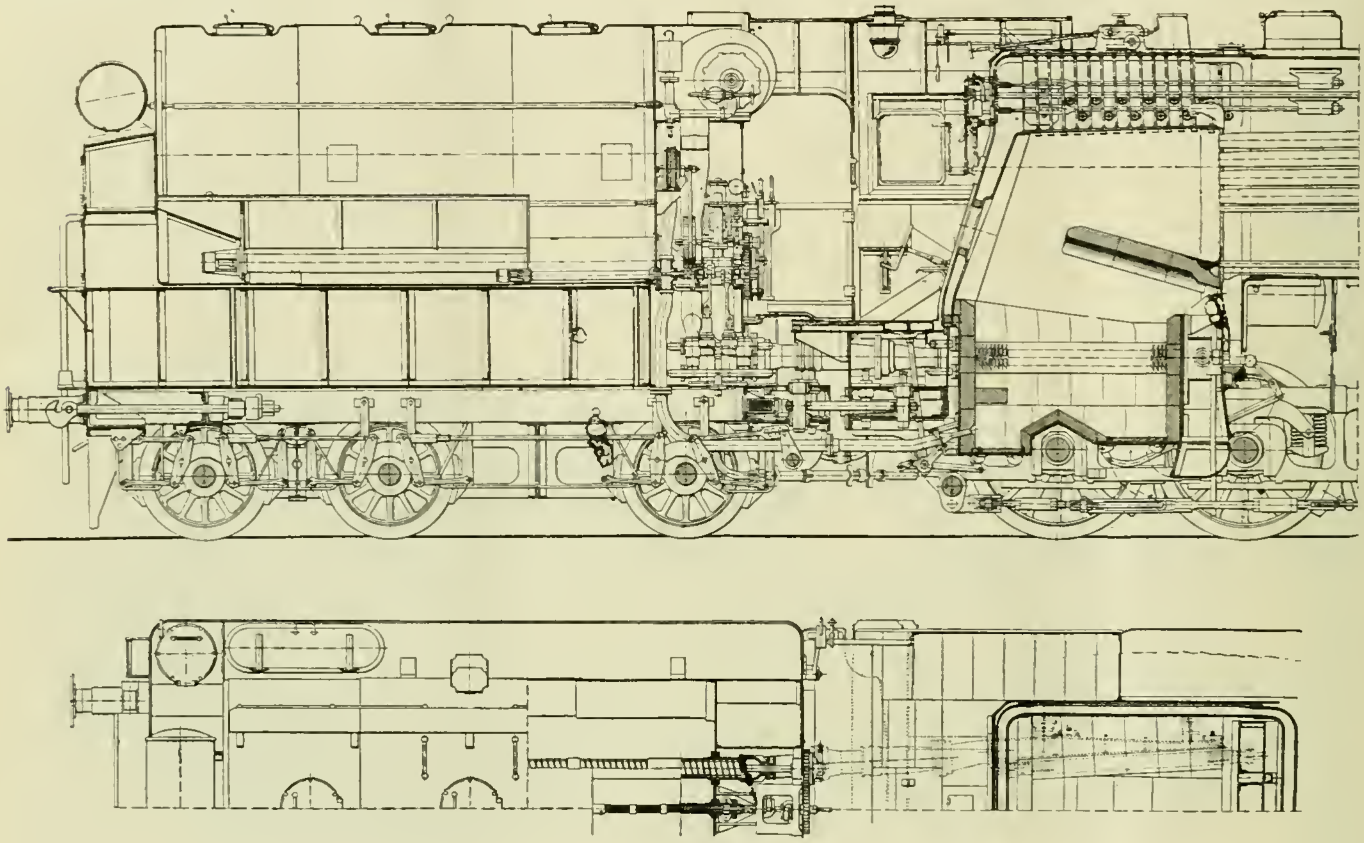
The main characteristics of the firebox may be described as follows: The air-pulverized coal mixture blown into the firebox only compresses a part of the air required for combustion in the form of primary air, the balance, or secondary air, being, as with an ordinary reciprocating steam engine locomotive, drawn in automatically by the blast pipe action or draught. The air-pulverized fuel mixture is blown into two lengthy nozzles facing one another below the firebox, where it is regularly decomposed into a large number of narrow streams or bands. These are formed at an angle of 90 deg., striking one another in the center of the firebox, where a violent vortex is produced. The rising pulverized fuel flames strike the strongly preheated secondary air below the brick arch. The special advantage of the A. E. G. pulverized-fuel locomotive consists in avoiding any kind of masonry in the firebox proper, therefore the most valuable heating surface for transferring heat as represented by the firebox is completely available for that purpose. The heated gases are deflected upwards at the end of the long arch at a very high speed, thus causing the slag particles to be granulated on the upper surface of the firebox, so that no slag clings to the tube orifices.

The two pulverized-fuel locomotives so far constructed by the A. E. G. Company were put to work hauling freight trains on the usual schedules on one of the sections of the main lines. A standard locomotive forms part of the train, and hauls the train to its destination, Neustrelitz, the pulverized-fuel locomotive coming off at Furstenberg, from whence it returns to Hennigsdorf. The latter engine frequently exerted to a pull of 1,300 tons, in addition to the weight of the standard steam locomotive, 115 tons, whereas the maximum load provided for on the section of railway is only 1,100 tons. The time schedule was also improved upon under these arduous conditions.

During the trial runs it sometimes happened that pulverized lignite and ordinary pit coal were stored above one another in the tender. This never gave rise to any inconvenience, in spite of the fact that a change over from one fuel to the other was effected in the course of the journey, and it is stated that those in charge of the locomotives that all the requirements of fluctuating steam consumption were easily met by the pulverized-fuel locomotive.

The advantages secured by the system may be summarized as follows: The fuel cost is reduced by the possibility of using lower grade fuel, the ability to use peat or lignite being a particularly valuable feature. The most satisfactory results obtained on the German lines were obtained by using lignite, this containing a high percentage of volatile components, thereby being utilized to the best advantage. This kind of fuel can also be used in conjunction with, or exchanged for, almost any kind of coal that may be available, and the combustion of fuel is more complete than for an ordinary type of firebox, there being only half of the surplus air, the heating of which is naturally a pure loss.

A saving of 20 per cent is stated to have been reached in the cost of steam production, and steam was raised much more quickly than with ordinary coal burned in the standard firebox. The control of the fuel in the firebox and its adjustment to the actual steam consumption is a point of considerable importance. The time required for cleaning the firebox is reduced to a minimum, and there are no fuel losses in discharging the slag. Thus the duration of a continuous run of a locomotive fired on this principle is limited only by the capacity of the coal bunker. Smoke emission is reduced to a minimum, and spark throwing is practically, if not entirely, eliminated. Greater cleanliness is secured for the crew, and, as with all mechanical firing the call upon the fireman's physical exertions is, of course, considerably less. It is also an advantage not to have to open the fire door for the constant replenishing of the fuel.



Details of Pulverized Fuel Burning Locomotive and Tender

The Kitson-Still Locomotive

A Kitson-Still internal-combustion locomotive the invention of Col. Kitson Clark, a director of the London, Midland, and Scottish Railway was built last year by Kitson & Co., Hunslet, Leeds, England, in association with the Still Engine Co. It is double acting, with internal combustion at one end of the cylinder and steam at the other end through which the piston-rod works. The water in the jacket is in connection with the boiler, and the excess heat from products of combustion assists in the production of steam in the boiler. The boiler is heated primarily by oil burners, and the steam generated is used for starting the engine. The two-stroke experimental engine, which has been installed for 10 years at Chiswick laboratory of the Still Engine Co., develops 400 indicated horsepower with the expenditure of 0.345 pound of oil per brake-horsepower-hour. To obtain such a result on a locomotive would be to save 60 per cent of the fuel bill. Toward such a result the designs are aimed but until the final tests with the locomotive are carried out it is not proposed to make any higher claim than a saving of 40 per cent on the fuel bill alone.

Diesel Engines for Railroad Traction*

The Various Types, Weights, Cost per Horsepower and the Different Types of Transmission.

By D. L. Bacon, Supervisor of Automotive Equipment, New York, New Haven & Hartford

Five years ago the Diesel locomotive was practically unknown on American railroads. Today there are more than thirty units operating in this country and fourteen Diesel rail cars in Canada. Other units of greater power are now undergoing test and a number of reputable engine builders here and abroad are ready to construct and guarantee performance on engines of almost any size and power. Because of this rapid development a great deal of interest is now being shown in the Diesel question, and many railroad officers are now studying the possible fields for applying this type of power. The entire subject is admittedly a new one, involving as it does, unknown engineering, operating, and economic factors, which at first must be estimated and predicted as accurately as possible, but which in the long run can only be determined by actual application.

Statistics for 1927 show that over one-half of the world's shipping built in that year was powered with Diesel engines: 1,200,000 Diesel horsepower in contrast to slightly over one-half million horsepower of reciprocating steam and less than one-half million horsepower in steam turbines. Diesel engines are now being built in sizes up to 15,000 hp. for stationary and power plant applications but these do not directly concern the railroad field.

The question which naturally comes to the mind of a railroad man is this: "Why has the Diesel engine been so widely used in marine application and yet failed until the last two or three years to find its way into the railroad field?" The answer is easily stated. The marine engine does not have to start under any appreciable load, whereas the locomotive's hardest task is to start and accelerate its train. The steam engine can exert indefinitely a very high tractive force when at a standstill and can continue to do so at increasing speeds, accelerating the train up to the point where the boiler becomes unable to supply steam as rapidly as the cylinders are using it up.

From there on the power is limited only by the boiler capacity. The Diesel engine, on the contrary, requires a preliminary cranking or turning over by some outside agency preparatory to generating its own power, just as is the case with an automobile engine. And, still in common with the automobile, a connection is needed between the crankshaft and the driving wheels which can be made suitable for starting or hard pulling on a hill and also for high speed operation.

Direct connection between a constant torque engine and the driving wheels gives essentially a constant tractive force of the locomotive at all speeds, hence maximum power can be obtained only at maximum running speed. At half speed, only half power is available, at quarter speed quarter power, etc., so that a large part of the time, and particularly when we are most in need of power, we are unable to get more than a fraction of what we paid for in buying the engine.

Probably the oldest continuous use of Diesels in railroad service is that of the Swedish State Railways, where Diesel engine rail cars have been in constant service since 1813. These cars are powered with an air injection Diesel having an electric generator applied to the end of the crankshaft. Current is led from the generator to the traction motors, mounted on the individual axles in the same manner as is customary on trolley cars. Twenty or more of these cars are now in service and this operation for a period of 15 years has shown great reliability and saving, both in fuel and maintenance, and demonstrated the entire feasibility of Diesel application to rail power if carefully engineered and organized. These cars are, in many respects, similar to the gasoline rail cars with which you are all familiar and which are now in general use for handling light passenger traffic on the Boston & Maine, the N. Y., N. H. & H. and other progressive roads throughout the country.

The great advantage of the electric transmission lies in the fact that through its use, any inflexibility of the Diesel engine is ironed out until the smoothness of power at the rail and the ease of starting and maneuvering is superior to that of any steam locomotive. The engine can be operated at its full rated power at any train speed while the electrical equipment automatically or with a minimum of attention from the operator, transmits this power (minus some 20 to 30 per cent electrical losses) and exerts it on the rail in tractive force appropriate to the train speed.

In common with other electrical machinery, the electric transmission is fool proof to a high degree and if treated with care has a long life. These are of course important factors from the railroad standpoint, as they protect the equipment in the hands of unskilled operators, promote reliability and serviceability and tend to minimize repair costs.

Because of these conditions the majority of Diesels in railroad service are equipped with electric drive in spite of its high first cost and weight. There has been constant effort, however, to devise other means of harnessing Diesel power and adapting it to traction purposes. Some of these have been more ingenious than practical while others show considerable promise.

A number of industrial locomotives built a few years ago in Austria and Germany had various forms of hydraulic drives in which an oil pump attached to the engine circulated fluid through oil motors on the axle of jack shaft. These were, however, all of low power and it is generally believed that transmissions of this type are not suited to powers in excess of 200 to 300 hp. Tests have just been satisfactorily completed, however, on a hydraulic transmission for use with a 600 hp. Diesel engine for switching service in South America.

In the locomotive, there is no doubt that although the required flexibility could be obtained without difficulty, the losses in the air compressor and in the air cylinders would be so great as to make the scheme impractical. There is a possibility, however, of making use of the exhaust heat of the Diesel engine to warm or superheat the air after it has been through the compressor and before expanding in the locomotive cylinders proper. In this way a considerable proportion of the heat otherwise lost through the exhaust pipe may be regained and it is hoped that in this manner a reasonable fuel economy can be secured, together with flexibility, while maintaining many of the conventional features of the steam locomotive. The wisdom of this last feature seems to be

*Abstract from a paper presented to the New England Railroad Club.

somewhat questionable as complication is thereby introduced. There seems to be a feeling, however, in some quarters that electrical apparatus should be avoided at all cost, due apparently to an unwarranted fear of attempting to introduce electricity on railroads where it had not previously been used. A large air transmission locomotive of this general type is now on test and it will be a matter of considerable interest to see whether the thermal economies obtainable with equipment of this kind can equal those of the electric transmission, or are worth the complications which they necessarily involve.

An extremely ingenious locomotive now undergoing tests in England, the Kitson-Still, is one which incorporates steam and Diesel cycles at opposite ends of double acting cylinders. Steam is generated in an oil burning boiler, the water from which also warms the Diesel cylinder jackets. This steam is used for starting the train and bringing it to a speed where the Diesel engine, already warmed up by the heat changes, will begin to fire, and its use is continued at low speeds to increase the tractive force available for acceleration. Steam is also available in the form of reserve power for short period overloads on grades, etc., or may be saved up between the stations, if these are closely spaced, for accelerating after the station stops. On the other hand in long non-stop runs, a small amount of steam may be used continuously in order to improve the economy of the power plant. Use is made of the cylinder jacket heat and exhaust heat of the Diesel engine, while running, to heat the boiler and to permit of cutting out the oil burner while the locomotive is under way. It may be shown by computation that the possible fuel economies of an engine of this type may considerably exceed those of other combinations but it remains to be seen whether the maintenance of the boiler, which is one of the things we would like to get away from, the steam engine with its valves and control gear in addition to the Diesel engine itself, may not more than compensate the possibilities of fuel saving. That this system, however, is not without promise is indicated by the fact that the motor ship Dolius, using a power plant of cylinder design, has covered some 200,000 miles in the last 3½ years showing excellent fuel economies under practical service conditions.

Another form of transmission which has possibilities is that of the clutch and gear drive, not unlike that used in our motor cars and trucks. It has been found by extensive experience that gears of the size and weight required for locomotive work cannot be thrown into mesh without injury when traveling at slightly different rotational speeds, as is the case with automobile gears. Therefore, all successful gear boxes incorporate the "constant mesh" principle. That means that the gears for all the different speeds are constantly engaged and running together but only one gear train at a time actually transmits power while the others spin idly upon their shafts. In some cases, as is the American practice, the gear chosen for operation is brought into mechanical driving connection with the shaft upon which it rotates, by a jaw clutch splined to this shaft and arranged so that it may be slid into engagement with a series of corresponding jaws machined on the sub of the gear. The favorite European practice for engaging the gear wheel with the shaft upon which it rotates, is to use a friction selector clutch for each gear so that any error in judgment on the part of the operator in shifting his gears will be taken up as a momentary sliding or slippage of the clutch plates, rather than destructive clashing and grinding, which is unavoidable with the jaw clutches and which reacts unfavorably on the entire transmission and engine.

Using this selector principle there have been built a number of rail cars, switching locomotives and even main line locomotives such as those furnished last year to the Russian railways and now an order for the Boston & Maine. The latter design merits considerable attention as many of the unsatisfactory features of other gear drives have been carefully avoided. One of these is the avoidance of bevel gearing in the final drive between the reduction gears and the driving wheels, because the bevel gear is relatively difficult to make for large torsional forces and to hold in satisfactory alinement. In this design the bevel gear has, therefore, been placed close to the engine where it runs at high speed and low load and all of the jack shafts in the gear box are mounted crosswise with the car and parallel to the driving axles. All of the heavy loads are taken by the spur gears. The selector clutches are each mounted on the ends of stub shafts and serve to connect the shaft to a sleeve upon which the gear is mounted. The clutches are therefore instantaneously removable for inspection or the renewing of worn friction discs without touching any other equipment. In accelerating a heavy train by engaging a clutch between an engine operating at a given minimum speed, and the driving wheels which are at first stationary and then slowly start to revolve, a considerable amount of heat is generated, depending on the minimum speed of the engine, the weight of the train and the time required to bring the train up to the speed for full engagement. This energy is so great that no attempt is made to absorb it in the selector clutches themselves, but in the case of the Krupp locomotive an additional master clutch is used, which is of such size that the heat energy evolved by the slip just referred to, can be absorbed without difficulty or danger. Assuming that the gears and clutches do their work properly, the main drawback to an arrangement of this kind is the fact that owing to a finite number of gear ratios, the train speed is seldom such that the corresponding speed of the Diesel engine will permit it to develop its maximum power and hence the tractive force curve of a geared locomotive is broken like a flight of steps, instead of being continuous, and the maximum power is not available at all train speeds.

A certain interruption is caused when shifting from one speed to the next resulting in cumulative shock as slack is taken up between the draft gear of the cars unless the equipment is skillfully handled.

In comparing the geared Diesel with the geared automobile it must be remembered that the automobile is light and has tremendous reserve power, while the locomotive is attached to a heavy train of cars and will presumably have no more reserve power than is necessary to fulfill its task. There is no doubt but the gear box may be built both lighter and cheaper than any other form of transmission and it remains to be seen whether its reliability, serviceability and ease of manipulation will be sufficient to make it a real competitor in the larger sizes of the more fully developed electric drive.

The investment cost of the Diesel locomotive is high, the operating costs are low, compared with steam practice. From this it necessarily follows that the harder the Diesel is worked the better its costs compare with steam, particularly if it can be worked long hours. Hence for a light schedule, steam is inherently cheaper while as the daily work is made harder, the Diesel costs become less than those of its predecessor. Just where this point comes of course will be determined largely by the basic factors applying in each case, but it appears that it may be safely assumed to lie in the neighborhood of 150 miles per day for light branch line operation on New England roads.

In conclusion, the survey of the Diesel locomotive question shows that within the last two or three years the question of design has progressed rapidly. Small units are out of the experimental stage and larger ones about to be tested will provide invaluable engineering experience and data. Limits which heretofore prevented the construction of Diesel locomotives of large power are being surmounted and the originally prohibitive weight per horsepower is being rapidly reduced. Reliability and fuel and maintenance economy have been fully demonstrated. The investment charges are bound to remain high but the possession of obsolete steam equipment is not a bar to the purchase of Diesel equipment for those applications to which the latter is suited. The apparently most promising applications are for switching in city yards, operation of industrial tracks, suburban service where the traffic density is not sufficient to warrant electrification, certain types of branch line operation or light local and mixed train service on light traffic lines and, particularly where fuel is expensive, long main line hauling.

Atmosphere Tests in Tunnels on the Chesapeake & Ohio Railroad

Conducted to Determine Conditions in Cabs of Freight Locomotives.

Investigation and tests have been made to determine the temperature, humidity, and the composition of the atmosphere in the tunnels of the Chesapeake & Ohio Railroad between Clifton Forge, Va., and Hinton, W. Va., and has been made subject of a report of the United States Bureau of Mines. The work was undertaken at the request of the railroad company and was conducted by R. R. Sayers, chief surgeon, U. S. Bureau of Mines; L. B. Berger, laboratory assistant, and W. P. Yant, supervising chemist of the Health Section of the Bureau of Mines Experimental Station of Pittsburgh, Pa. The purpose of the tests was to determine the conditions in the cabs of the locomotives while hauling trains through the tunnels.

Tests were made of two types of locomotives, classified by the railroad company as the H-6 and H-7. Both are of the articulated type, but the H-6 class is of the Mallet compound type whereas the H-7 operates all four cylinders at boiler pressure, thereby exhausting steam at a higher temperature than the H-6. It was desired to determine the relation between conditions on the H-6 and H-7 engines under comparable conditions of operation.

Tests were conducted in the following tunnels: Lewis, Alleghany, Second Creek, Big Bend, and Little Bend. Particular attention was paid to the Big Bend Second Creek, and Alleghany Tunnels, as these are the longest on this subdivision and grades are encountered in all three. East-bound freight trains are "fanned" by a ventilating fan at the west end of Big Bend Tunnel. Trains are kept behind the smoke when traveling east-bound in this tunnel; for this reason, tests were made of west-bound trains only. The Big Bend Tunnel has an ascending grade from each end, with a high point point or hump about 1,500 feet from the eastern portal. The Second Creek and Alleghany Tunnels have an ascending grade from west to east, and tests were made of trains traveling in this direction. Table 1 gives details of these tunnels.

The load pulled in all tests was at least the average tonnage for the locomotives used, and in some instances exceeded the previous maximum load pulled. In the majority of tests the trains were brought to a stop before entering tunnels. Although this is not a common practice during normal train operation, it was done on the test trains to obtain more severe conditions than usual.

Temperature measurements were taken in the tunnels with a wet and dry bulb thermometer of the sling type, and samples of the atmosphere were obtained for determination of the carbon monoxide, sulphur dioxide, carbon dioxide, and oxygen. These temperature measurements and gas samples were taken in the engine cab near the engineman or fireman. Several qualitative tests for hydrogen sulphide were made, but all were negative. On several occasions, blood samples were taken from one of the members of the test crew as soon as possible after emerging from the tunnels. None of these samples showed any significant degree of saturation with carbon monoxide.

Six test trips were made through the Big Bend tunnel, the first of which was operated eastbound with the tunnel fan blowing and the locomotive traveling in fresh air behind the smoke. The effective cab temperature on this trip was 85 deg. F. Four westbound trips were made with the simple articulated type locomotives, with trains varying in tonnage from 2,234 to 2,483 and one westbound trip was made with the Mallet compound locomotive and a train of 1,558 tons. The time in the tunnel on the westbound trip varied from four to five minutes. On the first westbound trip with the simple locomotive, steam was on full for two-thirds of the way through before the throttle opening was reduced. A thermometer about 18 in. from the roof and in the center of the cab, showed 140 deg. as the train left the tunnel and conditions were otherwise bad on this trip.

Table I—Tunnels on the Alleghany Sub-Division of the Chesapeake and Ohio in Which Tests Were Made

Name of tunnel	Length, feet	Height, rail to crown, feet (approx.)	Width, feet (approx.)	Grade, feet per mile	Direction of ascending grade	Number of tracks	Remarks
Little Bend......	668	21¾	27	21	East	2	No fan in this tunnel.
Big Bend........	6501	18	14	4 21	West East	1	Four ft. per mile west for about 1,500 ft. at east end and 21 ft. per mile east for about 2,979 ft. at west end. Fan at west end blows west to east.
Second Creek....	1561	18¾	14½	20	East	1	No fan in this tunnel.
Allegbany	4731	19½	26	30	East	2	No fan in this tunnel.
Lewis	4023	16	14½	60	West	1	Fan at east end blows east to west on west-bound freight trains. East-bound trains drift through.

The backs of the hands of one of the observers were severely blistered. Eye, nose and throat irritation was suffered and respiration was difficult. A marked improvement in conditions was noted immediately after the throttle opening was reduced. The effective temperature in the cab during this trip was approximately 123 deg. F., with a relative humidity of 90 per cent or more. In all tests in the Big Bend Tunnel except the one already mentioned, the amount of carbon monoxide was negligible as affecting health and safety. In that test one sample showed 0.06 per cent. This concentration would have no bad effects unless inhaled for at least one hour, and may be disregarded because exposure during passage through the tunnel is brief. There would be danger from this gas only if a train was stopped in the tunnel; then the carbon monoxide might markedly exceed the figure given.

Sulphur dioxide was present in all tests made in this tunnel, the maximum concentration found being 20 parts per million. Although this amount could not be considered dangerous, the irritating properties and odor of sulphur dioxide are decidedly unpleasant. Breathing through wet cotton waste gave relief from this gas.

As would be expected, the carbon dioxide content of the atmosphere was increased and the oxygen depleted, but conditions were never deleterious or dangerous. The maximum carbon dioxide found was 2.14 per cent, and the lowest oxygen 18.51 per cent.

On the three succeeding tests through the Big Bend Tunnel with the simple articulated locomotives pulling slightly greater loads than on the first trip, conditions did not approach the unbearable degree attained on the first test. The fact that a light throttle and the tunnel ventilating fan were used probably account for the improvement in conditions.

The single test Mallet compound locomotive through this tunnel indicated that temperature and humidity conditions were somewhat less severe than the average for the simple engines.

On only one of six trips through the Second Creek Tunnel was carbon monoxide found to an extent (0.09 per cent) which might be considered dangerous after exposure of 45 minutes to one hour. Sulphur dioxide was not found in dangerous amounts, the highest concentration being 20 parts per million. The increase in carbon dioxide and depletion of oxygen was not sufficient to be deleterious. The maximum carbon dioxide found was 1.15 per cent and the lowest oxygen 19.73 per cent. On the first trip through this tunnel, much discomfort was experienced from heat and humidity. However, on the next test the same engine was used with a slightly greater load and no marked discomfort ensued. This test was made using a light throttle through the tunnel.

Temperature and humidity conditions were found to be less severe with the H-6 (compound) locomotive than with the H-7 (simple) types through this tunnel, both on trains pulled by a single engine and on trains using an engine on each end. The effective cab temperatures for the former ranged from 101 deg. F., to 103 deg. F., while for the latter the range was from 111 deg. F., to approximately 123 deg. F. The time on the tunnel varied from 1 min. 10 sec. to 3½ min.

In tests through the Alleghany Tunnel the carbon monoxide content did not reach an amount that would be unsafe or produce discomfort for an exposure of one hour. Sulphur dioxide was not present in large enough quantities to be objectionable, the maximum concentration found being five parts per million. The increase in carbon dioxide and the oxygen depletion did not reach hazardous degrees. The maximum carbon dioxide found was 1.14 per cent and the lowest oxygen 19.68 per cent.

The temperature and humidity caused no marked discomfort during the majority of trips. In the last test, where two H-7 locomotives were used, the temperature and humidity were higher than in any other test through this tunnel and was uncomfortable, but conditions did not reach an unbearable degree of severity during the time consumed in making this trip. The fact that the Alleghany Tunnel is double-tracked may contribute the better conditions found. Temperature and humidity conditions were somewhat less severe for the H-6 engines than on the H-7 type. The time in the tunnel varied from 4½ to 12 minutes, and was 9 minutes on the last test.

Tests through the Little Bend Tunnel were of such short duration that samples of the atmosphere were not taken. The temperature and humidity did not cause discomfort.

During tests of passenger engines no discomfort was experienced from temperature and humidity. One test for carbon monoxide was made with engine pulling an unusually long train. The carbon monoxide content of the atmosphere was found to be negligible from a health and safety standpoint.

Of all the tests only two showed any appreciable amount of carbon monoxide, and this in amounts that would have no dangerous effects unless exposure was for 45 minutes or longer. There was no health hazard from sulphur dioxide, carbon dioxide, or depletion of oxygen content of the atmosphere for the time of exposure in these tests. There would be danger from the gases found only if a train was stopped while in a tunnel.

The chief cause of discomfort was the high temperature and humidity. In one test the temperature was high enough to cause surface burn. A similar test, with the engine worked under a lighter throttle, gave conditions that caused no marked discomfort, showing the relation that train manipulation bears to the conditions in the tunnels.

Table II—Effective Temperatures

Tunnel	H-6 Engines Load, tons	H-6 Engines Effec. temp.	H-7 Engines Load, tons	H-7 Engines Effective temperature	Direction of travel
			4996	85 *a*	East
			2234	123 (approx.)	
			2428	123	
Big Bend	1558	106			West
			2483	104	
			2386	123 (approx.)	
			4996	123 (approx.)	
			5023	123 (approx.)	
	3572	101			
Second Creek	7145	102	7145	119 *b*	East
	7036	103	7036	115 *c*	
			8191	111 *d*	
				115 *d*	
			3945	102	
			4195	98	
	2925	89			
Alleghany	7145	91	7145	107 *b*	East
	7036	100	7036	103 *c*	
			8191	123 (approx.) *d*	
				98 *d*	

a Tunnel-ventilating fan on; engine traveling in fresh air behind smoke.
b H-6 head end. H-7 rear end.
c H-7 head end. H-6 rear end.
d H-7 head end. H-7 rear end.

Although many of the effective temperatures given are above those that would be practical for long exposure, men are able to work for short periods—10 to 15 minutes —in temperatures up to 135 deg. F. with 100 per cent relative humidity without marked inconvenience; and exposure of one hour is not practical. An exposure of one hour to 98 deg. F. with 100 per cent relative humidity causes the pulse-rate to be greatly increased, as well as causing a marked increase in the body temperature and body metabolism, even when the individual remains at rest.

The maximum endurance found at 105 deg. F. saturated air is approximately 45 minutes and at 117 deg. F.

the limit of endurance is 15 minutes; 135 deg. F., effective temperature could not be borne for any length of time by a man with a skin directly exposed. Thick clothing will protect or, in other words, will insulate the body from such temperatures. Work has been performed at 135 deg. F. effective temperature by using special suits of thick felt. Under these circumstances work has been performed for 15 to 20 minutes.

The Design and Proportion of Locomotive Boilers and Superheaters*

Boiler Design for Increased Locomotive Capacity

By C. A. Brandt, Chief Engineer, The Superheater Co.

The best measure of railroad operating performance today is condensed in the unit Ton-miles-per-train hour. There has been a steady increase in this figure during the last thirty years. No actual figures expressed in this term for the railroads in Canada have been found, but I recollect that for the railroads in the States the increase in gross-ton-mile-train hour was about 42 per cent from the year 1906 to 1916. From 1916 to 1925 there was an increase of 57 per cent. No doubt the railroads of Canada have equalled or exceeded this record.

The problem that has confronted the locomotive designers in accomplishing this result has been a very difficult one, since increasing the sustained power of a locomotive by direct methods involves an increase in the physical dimensions and weight on the drivers. The weight limitation, with few exceptions, is 60,000 to 65,000 lbs. per axle, and determined efforts have been made by some of the largest railroad systems in the country to keep the weight below 62,000 lbs. per axle, and thus lessen the destructive action of the driving wheels on the tracks. Our efforts, then, must be directed towards the production of a locomotive which will develop the highest possible power per unit of total weight, or, stating it another way, one that will have as small a weight as possible per horsepower developed. Such an engine must, of necessity, have a very high thermal and mechanical efficiency.

There is little hope of increasing driver weight or reducing the factor of adhesion below that which has been used on recently designed locomotives. The factor of adhesion usually referred to is the weight on drivers divided by the maximum tractive effort, but we are now recognizing that the true factor of adhesion is the weight on drivers divided by the maximum turning effort, which may be as high as 30 per cent greater than the average. When the cylinder arrangement is such as to give a nearly uniform turning movement, the true factor of adhesion has been reduced to nearly 3½.

We shall in this paper discuss principally the problems of the boiler and superheater, or the steam-producing part of the locomotive. Usually the boiler problems are discussed independently of the balance of the locomotive. This cannot well be done without some reference to the locomotive in general, as the engine and the boiler are so closely related, from a standpoint of construction as well as performance, that one part cannot be easily changed without disturbing its relation to the other.

The design of the boiler and superheater will, in the final analysis, determine not only the efficiency at which the steam is produced but also the efficiency and capacity of the engine, since the steam consumption of the cylinders depends largely on the superheat and pressure of the steam. Briefly this relation works out as follows:

The mean effective pressure in the cylinders determines the capacity of the locomotive for all speeds if there is a sufficient amount of highly superheated steam available, and the higher the superheat and the initial boiler pressure is, the higher the M. E. P. and the more efficient and powerful the engine will be. After the steam leaves the boiler, it must pass through the superheater throttle and steam pipes. This reduces the steam pressure, due to the frictional resistance of the steam passing through these parts, and it is of the utmost importance that this pressure drop be kept at the minimum.

Here is where the superheater presents a very difficult problem as the steam area through the superheater as well as the superheating surface that can be installed is determined by the diameter of the boiler. Then again, the horsepower capacity can be raised by reducing the back pressure on the pistons. As the vacuum in the smokebox creates the draft which determines the amount of coal that can be burned, it is of the greatest importance that the draft loss through the flues be reduced to a minimum by increasing the gas area through the boiler, which again is determined by the boiler diameter and superheater. It is thus seen that the diameter of the boiler has a greater importance than any dimension of the boiler design and the greatest possible diameter of the boiler should be used in every case.

Of course, there are other factors that affect the mean effectiv pressure of the cylinders, particularly the valve gear which determines the valve travel. The importance of long valve travel which produces long port openings at short cut-offs and longer exhaust port openings, has long been recognized, and its use has been incorporated in many recently designed locomotives.

Locomotive Ratios

The problem of cylinder and boiler proportion or ratios have been the subject of intense study by many able men since the first locomotive was built, and it would seem to the layman that the laws governing its design should have been all figured out and settled by this time. Such, however, is not the case, and suggestions for improvements are continually being made.

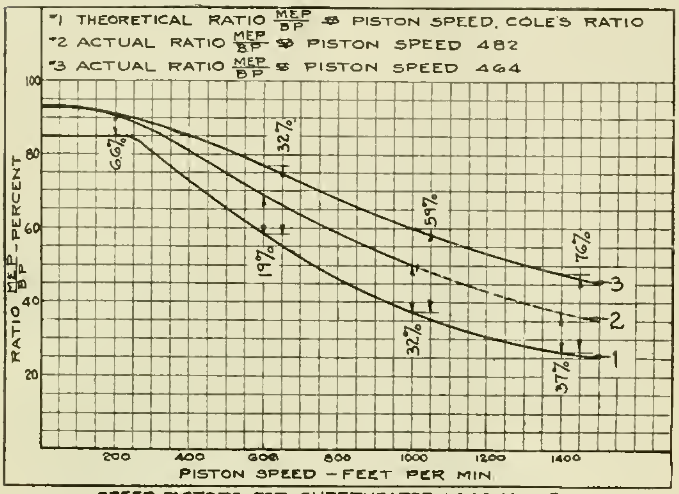
Before we start discussing the design and proportion of the boiler, it is well to first determine what the maximum power is that a given cylinder can develop so we know what to aim at.

Speed Factor

The falling off of tractive effort of a locomotive as the speed increases is caused by a reduction of the ratio between mean effective pressure in the cylinders and the boiler pressure. This ratio plotted against piston speed is used to calculate the tractive effort at various speeds and is usually termed "speed factor." The factor which

* Abstract of a paper presented to the Canadian Railway Club, Montreal, Que.

has been used universally in determining the tractive effort and the maximum cylinder horsepower was determined some years ago by Mr. F. J. Cole, and is plotted as curve No. 1 in Fig. No. 1. Developments of the most recent locomotives, however, have shown that it is possible by the use of high superheat and correct proportioning of the boilers and cylinders to raise this ratio considerably.



SPEED FACTORS FOR SUPERHEATED LOCOMOTIVE

Fig. 1

On the same figure have been shown curves No. 2 and No. 3 which illustrate this ratio of speed factor obtained on carefully conducted tests on two recently constructed locomotives.

It will be noticed that a remarkable improvement has been made on these and other similar locomotives, and these curves present the best picture that can be painted to illustrate the improvements in locomotive design of today. The speed factor shown in curve No. 2 can safely be used for freight locomotives with wheel diameters up to 70 in. and curve No. 3 for high speed passenger locomotives when a Type E superheater and a feedwater heater is used.

With the above suggestion for determining the maximum tractive force for starting and at speeds, we can now calculate the maximum cylinder horsepower that can be developed with a locomotive using highly superheated steam.

Steam Consumption

The next step is steam consumption per indicated horsepower. In the calculations for the steam demand of a superheated locomotive, a figure of 20.8 lb. per horsepower-hour has been used universally. This was also proposed and used by Mr. Cole and was based on steam around 200 lb. pressure and 200 deg. superheat.

Since the introduction and use of 300 deg. or more of superheat obtained with the Type E superheater, coupled with a somewhat higher pressure and better steam distribution in the cylinders, this steam rate has been materially reduced.

Numerous tests have been made showing a steam rate as low as 15 to 16 lb. per indicated horsepower-hour at maximum capacity. It is, therefore, suggested that when a locomotive is designed to use steam superheated to 300 deg. F., a pressure of from 225 to 275 lb., a feedwater heater and large grates, a steam rate of 17½ lb. per indicated horsepower including auxiliaries, can be safely used.

Boiler Design

With these important points in mind, we now come to the question of the design of the boiler, superheater, feedwater heater, etc. Experience shows that some locomotives are better steamers than others and some are not very good. It is evident, therefore, that there are some features in the design of a poor boiler that impose a limit on the development of higher power or reduce the efficiency as compared with others. Our efforts should, therefore, be directed toward finding out where the weak link is in a particular design and discover the ratios or proportions that would show improvement.

My first intention was to discuss the high pressure water tube firebox boiler only, this being the problem that is today most intensely studied. By high pressure is meant boilers carrying upwards of 300 lb. pressure. When reviewing the accomplishments, however, that have been made in the design of the most recently constructed standard type of locomotive having a Type E superheater and a feedwater heater with a pressure around 225 to 250 lb., it appeared that the most valuable contribution I could make at this time was to analyze the reasons for the remarkable improvements made in the last ten years, using the conventional designs.

There has recently been placed in service a 4-6-4 passenger locomotive that has developed 4,295 i.hp. with a weight on the drivers of 42.3 lb. i.hp., and a total weight per engine of 80 lb. per i.hp. when pulling a train of 26 steel passenger coaches at 67 m.p.h. When you find that this has been done with a boiler and superheater efficiency of 78.6 per cent, an average steam consumption of 17.14 lb. per hp.-hr. and a coal consumption of 2.09 per i.hp.-hr., including all auxiliaries, then you must sit up and take notice. These figures are average results of many tests, and the best average results on any single run with this train were an average boiler and superheater efficiency of 84.2 per cent, a steam consumption per i.hp.-hr., 15.04 lb. and 1.89 lb. of coal fired per i.hp.-hr. This included all auxiliaries. The coal per drawbar hp.-hr. was 2.68 lb. and the maximum temperature of steam was 750 deg. F.

Fig. 2 shows the comparison between tractive force and

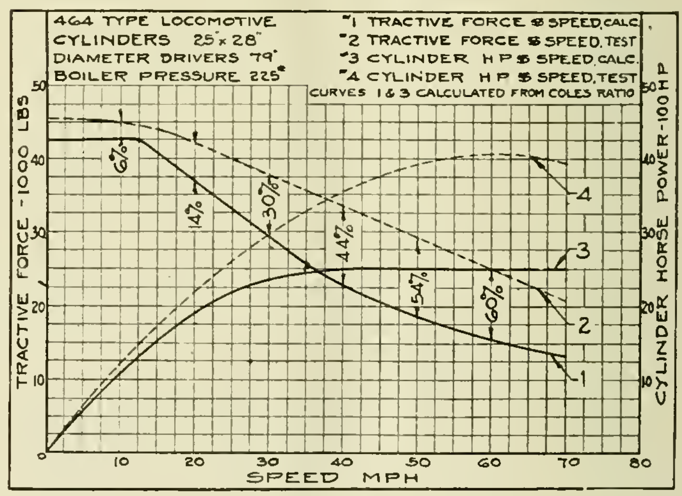


Fig. 2

cylinder horsepower calculated from Cole's formula and the tractive force and power actually obtained from test.

A recent large freight locomotive of the 4-12-2 type has developed a maximum of 4,917 i.hp. with a weight on the drivers of 72.3 lb. per i.hp. and total weight of 101 lb. per i.hp. This is very remarkable for a heavy freight locomotive and represents, as far as I know, the heaviest power output recorded.

Another locomotive of the 4-8-2 type having a total engine weight of 95.8 lb. pe i.hp. pulled a freight train of 122 cars of 9,315 tons at a maximum speed of 34.8

m.p.h. and an average speed of 18.25 m.p.h. with a coal consumption of 2.59 lb. per drawbar hp.-hr., including all auxiliaries. This performance was equalled by another locomotive of the 2-8-4 type hauling 9,324 tons at 18.3 m.p.h. average speed on 2.50 lb. of coal, per i.hp.-hr. The drawbar pull-speed for this 4-8-2 type is shown in Fig. 3.

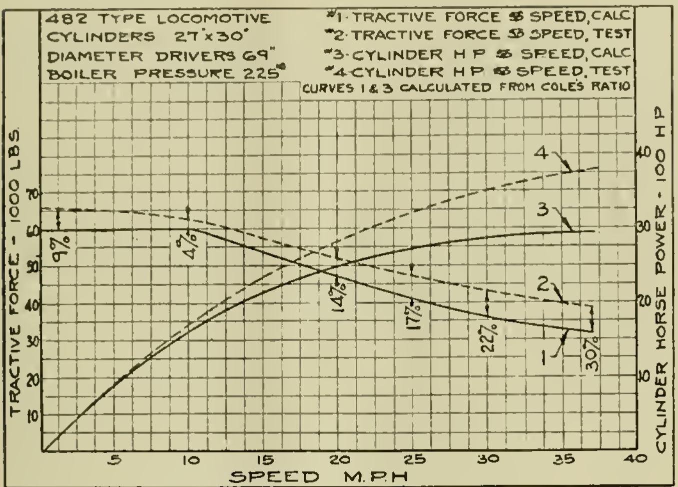


Fig. 3

All of the above mentioned engines are equipped with type "E" superheaters, feedwater heaters and large grate areas. Many other engines of the same characteristics have been constructed within the last few years but test data are not yet available.

High Steam Pressures

There have been several reciprocating steam locomotives built in the last few years carrying over 300 lb. boiler pressures, all with water tube fireboxes and compound cylinders as follows: one with 350 lb. and one with 400 lb. by the D. & H. Baldwin No. 60,000 with 350 lb. and the Schmidt Henschel engine carrying 880 lb. and 200 lb. The performance of the D. & H. engine is not known, but that of the 60,000 was published in the March, 1927, issue of Railway and Locomotive Engineering.

The increase in the theoretical thermal efficiency by the use of high pressure is well known to all students of this subject. Mr. Lawford Fry pointed out in a recent paper that the theoretical thermal efficiency of the so-called locomotive cycle will increase from 14.2 per cent at 220 lb. to 17.9 per cent at 450 and 20.7 per cent at 600 lb. absolute pressure.

To obtain the benefit of high pressure it is clear that a high ratio of expansion must be used by compounding and the three cylinder arrangement makes this quite simple and practical. When we consider the remarkable efficiency now obtained with a 225 lb. pressure engine with type "E" superheater and feedwater heater, it seems that in order to get a return on the investment and maintenance cost of water tube fireboxes and compound cylinders a steam consumption of 10-12 lb. of steam per i.hp.-hr. should be obtained and a coal consumption well below 2 lb. per draw bar horsepower hour.

Water Tube Firebox

It was a courageous step when the steam pressure for staybolt boiler was increased from 200 to 250 lb. Thousands of these are now operating successfully. Recently 265-275 and 300 lb. have been used on a few engines. Whether a 300 lb. stay bolt boiler will prove satisfactory only experience will tell. The general opinion among the best authorities now is that above 250 lb. to 275 lb. pressure water tube firebox is the safest and most desirable.

The water tube firebox is an old design. It was first designed by the eminent Russian engineer, J. Brotan, 30 years ago. Several engines were built in 1904. Mr. C. Noltein reported on these to the International Railway Congress in 1910 as being satisfactory.

The reason why it has not been put into general use throughout the world is probably due to the great difficulties experienced and time required in keeping the water tubes free from scale. Where good feedwater is available we know from experience of the New Haven and Delaware & Hudson R. R. that a water tube firebox can be satisfactorily maintained. Unfortunately there are only a few places in the world where pure water for locomotive use is available. In localities of bad or even normal water conditions the loss of time and cost of keeping the water tubes clean might be very high. It appears therefore logical that the only water tube firebox that can be satisfactorily used is one where only pure or preferably distilled water is used in the water tube end of the boiler.

This paramount requisite for successful operation of water tube firebox is incorporated in the principle used by the Schmidt-Henschel engine referred to where the steam used by the cylinders is evaporated by means of indirect heat from steam condensed in heat interchange coils located in the steam drums, the condensate returning to the bottom of the firebox headers forming a closed cycle.

While this design was particularly evolved for a high pressure engine, this form of construction may prove of advantage with lower pressure as well. The design and construction of the water tube firebox recently built in this country has been very fully described in the technical papers and we need not take further time to discuss them. It would seem, however, that the many apparent advantages of a water tube firebox will be developed into a practical construction supplanting the staybolt firebox.

Boiler Ratios

The standard of excellence in design should be the engine that has given the highest power output per unit of total weight, weight on drivers and per 1,000 lb. of theoretical tractive effort. These units will give you an accurate picture, not only of the excellence of the general proportions and over-all efficiency, but also of the refinement in the mechanical design. Only locomotives in approximately the same class of service should be directly compared with each other.

It is to be regretted that actual dynamometer tests are not available for all of these modern locomotives, but it is known that the performance of the others shown has been excellent and probably equalled those for which tests have been published.

It is evident that it is impractical to lay down a definite rule or ratio that would fit any given condition. All rules and ratios must be used with great care and analyzed in the light of actual conditions to be met. There are certain fundamentals, however, that must not be lost sight of and it is the intention to present and tabulate here the facts available to aid in properly designing a locomotive boiler with as little theoretical speculation as possible and at the same time give assurance that the best possible locomotive will result.

Boiler Efficiency

When the performance of a locomotive boiler is analyzed, one immediately notices that the efficiency decreases rapidly as the rate of firing increases, or from about 75 to 80 per cent with a coal rate below 40 lb. of coal per square foot of grate per hour to about 40 to 45 per cent efficiency with a coal rate of around 200 lb. per sq. ft.

A number of curves are plotted in Fig. 4, showing the boiler efficiency vs. the rate of firing. It will be noticed that some curves are considerably higher than others while other curves show a different slope. It is thus clear that there must be some factors entering into the proportion of the boilers that have a great influence upon the efficiency for any given rate of firing, as well as upon the rate of decrease as the rate of firing increases. The principal factors that are responsible for the great heat loss, as the output increases, are as follows:

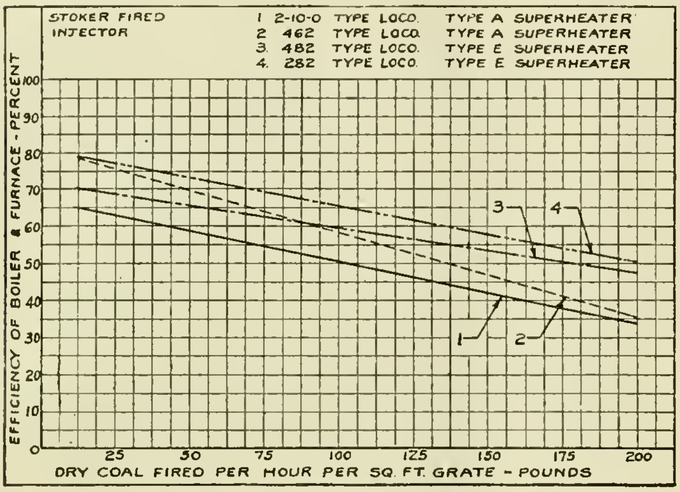


Fig. 4

First—Imperfect combustion producing carbon monoxide.

Second—External radiation from the boiler and firebox.

Third—Loss of heat in the smokebox gases.

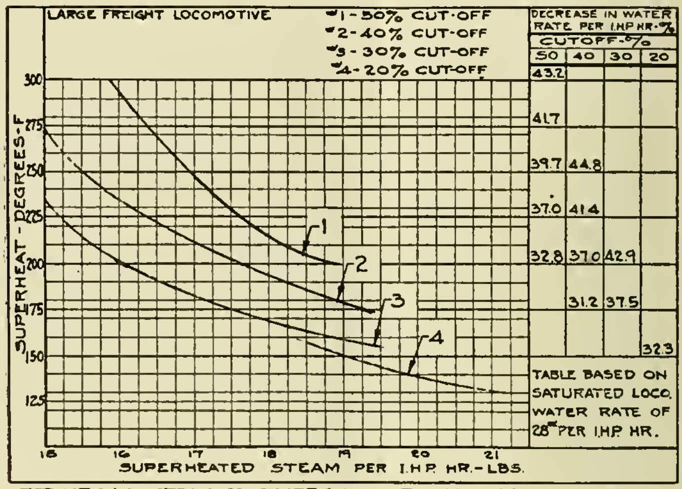
Fourth—Unburned fuel escaping from the boiler. This heat loss increases very rapidly on the older type of boiler as the rate of firing increases. Numerous tests have shown that this heat loss will run from 15 to 20 per cent at a 60-lb. coal rate, up to as high as 50 per cent when the coal rate is 200 lb. per sq. ft.

This is due to the fact that the grate area and furnace volume are too small to give the carbon and volatile combustible time to mix intimately with the oxygen and burn before they enter the flues and is also due to the small gas area through the boiler, which causes too high a gas velocity and draft loss through the flues. It is clear, therefore, that a great gain in boiler efficiency will result from any effort that will improve these conditions.

The Superheater

A discussion of the boiler can not well be held without reference to the superheater. The importance of high sustained superheat is well known. Since the first steam locomotive was built, there has been no device or feature of design added to the locomotive up to the present date that has had such a beneficial effect upon the locomotive efficiency as superheated steam. This fact has been proven so many times by numerous tests throughout the world that it is accepted among engineers as is the law of gravitation. The fact, however, that the cylinder efficiency increases as the temperature of the steam increases, even beyond those that have been common practice, is not quite as well understood. The effect of increased superheat or steam consumption is shown clearly by the various curves in Fig. 5 taken from tests and illustrate the fact that superheat follows the law of increasing return. The production of high superheat on the modern locomotive, however, has been made more and more difficult, due to radical changes in the boiler proportion of very large engines, and it has become necessary for the superheater designer to meet this condition by enlarging the capacity of the superheater. This has been done by increasing the superheating surface, the necessity of which is clear from the following discussion.

Less heat is left in the gases entering flues, due to the greater heat absorption in the large fireboxes, which decreases the heat available for superheating. The use of feedwater heaters and exhaust steam injectors also, by



REDUCTION IN STEAM CONSUMPTION DUE TO INCREASE IN SUPERHEAT

Fig. 5

reclaiming heat that would otherwise be lost, reduces the rate of firing that is required for same evaporation and naturally decreases the amount of heat offered to the superheater and flues.

On the extremely large locomotives of today the steam space in the boiler has been substantially decreased. The steam liberating surface has also decreased in proportion to the total amount of water delivered by the boiler. Both of these conditions have contributed to a marked increase in the amount of water that is carried by the steam from the boiler to the superheater. As the evaporation of 1% of moisture requires as much heat as a superheat of 17 deg. it is a difficult task to provide a superheater that is adequate as steam may carry 5%, or more of moisture when it enters the superheater units. This condition not only points to the necessity for a greater capacity superheater, but to the importance of proper handling of the water level on the road.

The increased demand for operating trains at higher speeds, requiring more steam for a given size of locomotive requires superheaters of greater capacity, in order that these demands on the boiler may be met without a too serious sacrifice of boiler efficiency and evaporating capacity. The greatest possible total steam area through the superheater is also very important as it will result in less pressure drop through the superheater units. The result of this condition has led to the development of a somewhat different arrangement of the superheater unit in a design usually referred to as Type "E."

Results Obtained With Type "E" Superheater

The characteristics of the type "E" superheater, which have been referred to above, have given very satisfactory results in service and on tests.

Fig. 6 shows the results of tests conducted during 1923 and 1924 on some larger and more modern locomotives, viz., the I—1st class, 2-10-0 type engine of the Pennsylvania. Curve 1 on this sheet shows the performance of one of these engines having a type "A" superheater, while curve No. 2 shows the performance of one of an identical engine with a type "E" superheater. It will be noted that the fuel economy is pronounced throughout the entire range of power developed on the test.

Figure 7 indicates the boiler efficiency obtainable by the type "E" superheater on the same locomotives as are referred to in Fig. 6. Curve No. 1 in Fig. 7 is the boiler efficiency of a locomotive with a type "A" superheater and curve No. 2 of the same class of engine with a type "E" superheater. Both were for tests in which the live steam injector was used.

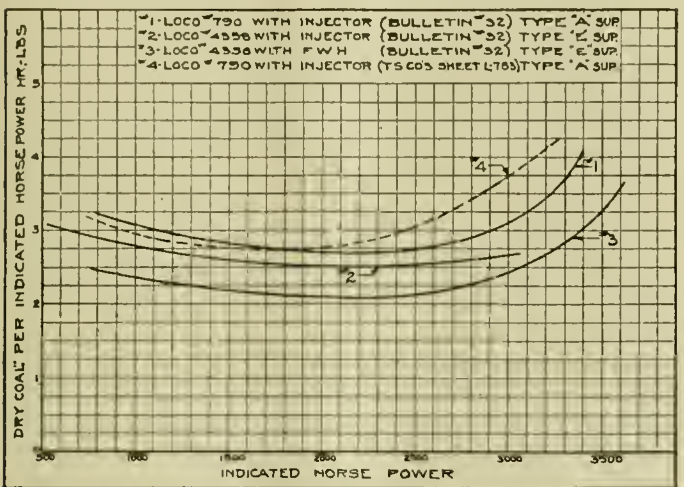


Fig. 6

In the above references to test results and from the figures and curves shown, it will be clear that it is possible with a type E superheater to increase the sustained capacity at high speeds by at least 20 to 25 per cent over that obtainable with a properly designed Type A superheater. For large locomotives this is also possible without increasing the weight of the locomotive to a great extent wherever the boiler is properly proportioned for the Type E

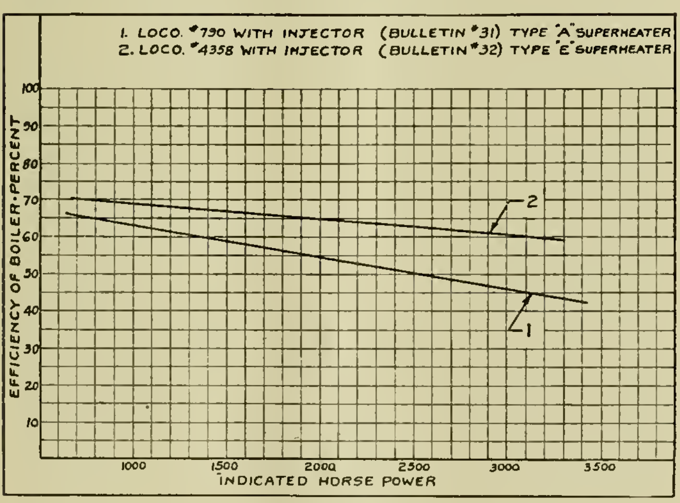


Fig. 7

superheater. Where the axle loads on any railroad have reached the permissible limits and it is necessary to have a still more powerful locomotive, the necessity for and the advantages of a Type E superheater are clearly indicated. Most of the recently constructed high capacity locomotives are equipped with the Type E superheater and there are now about 1,500 installed.

Feed Water Heating

Before closing this paper it could not be considered complete without some reference to the part played by the principle of preheating of boiler feed water with waste exhaust steam. No locomotive can be considered efficient without being equipped with some means of doing this. The reasons therefor are well known, but will be summarized briefly:

1. It increases the maximum evaporative capacity by 15 to 20 per cent on any boiler, no matter how efficient it be in itself.
2. It decreases the weight of the boiler by 12 to 14 per cent for equal capacities.
3. The first cost, or capital investment, will not be any greater for a boiler with feed water heater as compared with one without having the same capacity.
4. It increases the cylinder horsepower due to lower back pressure on engines.
5. It increases the capacity of the tender by 20 per cent.
6. It decreases the cost of boiler maintenance because from 15 to 20 per cent of the feed water is returned in the form of condensed steam or distilled water. It also reduces the expansion strains of the boiler, provided that the feed water heater is so designed that cold water cannot be pumped into the boiler at any time.
7. It increases the combined efficiency of the boiler and feedwater heater by at least 15 per cent net, as it recaptures this amount of heat from the waste steam exhausted from the cylinders.
8. It reduces the total net weight of the engine and tender.

Railway Freight and Passenger Receipts

American railroads do a bigger transportation job at cheaper rates than any other country in the world.

The railroads last year received an average of 1.080 cents for moving a ton of freight one mile. This represents a decrease of 15.3 per cent as compared with receipts in 1921.

For transporting a passenger one mile, the railroads received last year an average of 2.896 cents, a decrease of 6.2 per cent as compared with 1921.

These decreases are the results of innumerable individual rate readjustments which have been going on throughout the country in the last few years.

In an analysis of this situation, just issued, the Bureau of Railway Economics says:

"In the freight and passenger services, the decrease in revenue in 1927 was relatively greater than the actual decline in traffic. Respecting the other services, known factors do not exist by which to measure the physical amount of the service rendered.

"The explanation for the greater drop in revenue than in traffic lies in the declining price of transportation in 1927, that is, what the public paid the railways per transportation unit. In both the freight and the passenger service, average receipts per unit were lower in 1927 than in any previous year since 1920.

"The average receipts per ton-mile and passenger-mile year by year from 1921 to 1927, are presented in the following table. These averages measure with a fair degree of accuracy the respective price levels of the two principal kinds of transportation service rendered by the railways."

Receipts Per Ton-Mile and Passenger-Mile, 1921-1927

	Receipts per ton-mile (cents)	*Receipts per passenger-mile (cents)*
1921	1.275	3.086
1922	1.177	3.027
1923	1.116	3.018
1924	1.116	2.978
1925	1.097	2.938
1926	1.081	2.936
1927	1.080	2.896

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High Marks of Efficiency

Elsewhere in this issue will be found an article on fuel economy and maintenance costs, which includes a tabulation of statistical items and numerous unit costs on 40 of our principal class one railways.

The tabulation under the caption of "Facilities and Comparative Results From Operation," is somewhat unique in that into it there has been introduced two new yard sticks or units of measurement, namely, repair costs to locomotives based on their size or tractive power, and the cost of fuel in cents per 1,000 gross ton miles of freight moved.

We have become so accustomed to speak of locomotive repairs in terms of so many thousand dollars per annum, or so many cents per mile run that the size or capacity of the engines has been almost completely lost sight of, although it is a most important factor. Therefore, it was thought a new or additional unit cost, based on the average tractive power would be helpful in making comparisons.

It will be noted that annual cost of repairs per unit varies from $3,963 to $17,504 or a difference in range of about $13,540, while the difference in the cost per mile varies from 18.6 to as high as 55.2 cents or a spread of more than 36.6 cents.

The new unit or yard stick based on tractive power or size is secured by dividing the average annual cost of repairs per unit by the average tractive power, which gives the cost in dollars per unit of tractive power.

It will be observed that using the above method, the cost per 1,000 lbs. of tractive power varies from a minimum of $97 to as high as $466 or a spread of about $367. Thus it will be seen that the wide range or difference in costs on the different lines, except one, is pretty much the same no matter which yard stick is used.

Figured on a percentage basis, however, and using the minimum or lowest cost of each, the results are as follows:

Lowest cost per unit, $3,953; highest, $17,504; range of $13,540; 387 per cent.

Lowest cost per mile, 18.6c; highest, 55.2c; range of 36.6c; 50 per cent.

Lowest cost per T. P. Unit, $97; highest, $466; range of $367; 380 per cent.

From the above it will be observed that the new yard stick shows about the same range of unit costs as one of the two methods that are in common use, but much greater than the cost per mile run basis.

It must be borne in mind that these wide variations are largely influenced by the extremely high costs reported by one carrier whose figures, if correctly reported for the year designated, are not only out of all proportion, but represent an unwarranted or shameful waste of funds. The cost of the actual wear and tear of locomotives from service during the specific period would not even approach the amounts shown as having been expended.

The average annual unit costs of the 40 lines shown in the table is $7,620 while the average cost per mile run is 28 cents. These figures compare favorably with the prevailing expenses under average normal conditions. Therefore, the maximum cost charges shown by one of the carriers evidently includes expenses other than actual service wear and tear in that particular year.

The same comments with respect to excessive repair costs for the year shown also apply to the average repair costs per 1,000 lbs. of tractive power.

The high mark of efficiency to which attention is invited is the item covering the cost of fuel per 1,000 gross ton miles, which it will be noted ranges from 8.6 to 32 cents, a range of almost 4 to 1.

We have become so accustomed to show fuel consumption, or the pounds of coal used per 1,000 ton miles, that the prices or cost feature has often been overlooked and it seems to us, that, as the cost or expense is in the last analysis the real crux of the whole thing, that the pounds of coal used should be translated into money, so that all the factors may stand out plainly in making comparisons.

To many who scan the monthly performance sheets of their own and other lines, the difference of a few pounds of coal per 1,000 ton miles does not really mean much. The unit employed does not in the absence of conversion into money value carry much weight, but, when we then cast up alongside of it the actual cost in cents ranging as it does from 8.6 to 32 cents, the true value is apparent.

The Chesapeake & Ohio having made a splendid record in fuel economy, plus the advantages of low cost per ton that they enjoy, lead in this display with the exceptionally low cost of 8.6 cents per 1,000 gross ton miles. The line with highest cost consumes about 39 lbs. more coal per 1,000 ton miles and pays more than three times as much for it. If the price of fuel was $1.71 per ton to both lines then the cost per 1,000 gross ton miles would be 8.6 and 11.97 cents instead of 8.6 and 32 cents respectively.

It will be noted that on six lines with fuel costing from $1.50 to $2.00 per ton, the quantity used per 1,000 gross ton miles varies from 101 to 166 lbs., the average being 143 lbs.

There are sixteen lines that pay from $2.00 to $3.00 per ton and the amount used per 1,000 ton miles varies from 90 to 195 lbs., with an average of 143 lbs.

Ten lines pay from $3.00 to $3.50 per ton and the amount used per 1,000 ton miles varies from 111 to 160 lbs., with an average of 135 lbs.

Eight lines pay $3.50 per ton and up, and use from 111 to 163 lbs. per 1,000 ton miles, with an average of 129 lbs.

In addition to the above many interesting comparisons may be made of the quantity of fuel consumed, the price per ton, the cost per lb., and the annual amount consumed per 1,000 ton miles and by a combination of these items with other factors of train movement expenses for past and present years, there will be apparent not only what has been done, but to what extent further economies may be effected, particularly in the item of fuel.

To those who visualize lbs. of coal in terms of cents of expense per 1,000 gross ton miles, we commend this additional yard stick for use in making a subdivision of the various items of expenses involved in freight train operation. The method of expressing the average annual costs of locomotive repairs, based on the average tractive power of all locomotives, we think, may prove a helpful addition to the rather arbitrary formulae now commonly used.

High Pressure and Strength in Steam Boilers

In connection with our recent articles and editorials favoring the use of higher steam pressures as an inviting field in which to achieve greater economy in the operation of prime movers, we find some interesting points with respect to boiler design by an English engineer of many years' experience, but whose views in the past have not always passed unchallenged. In view of the rather extraordinary points brought out by him, steam engineers will undoubtedly, not only test out some of the features or claims he has made, but will also keep in close touch with the author and others who may continue research along similar lines.

The chief engineer of the Manchester Steam Users' Association for the past thirty years or more, has during that period made annual reports of progress in the matter of boiler design, and now, on his retirement from that important position, he has rendered a final report. The complete file embodies facts and data that gives the designer of steam boilers much food for thought.

Among the points brought out is a criticism of our general tendency to move forward as it were in a straight line, following the results of the application of lessons learned from experience and that as a result of this together with fallacious reasoning of mathematicians, we have gone on for years increasing the thickness of boiler plate in the belief that it is the right way to meet increasing pressures. In the light of more recent conclusions of the author, many boilers would be just as safe and in some respects safer, were the materials thinner than called for by the arbitrary rules generally accepted.

The whole thing seems to hinge as it were on the difference between plastic and elastic strength. About the latter a good deal has been known for many years and upon it most accepted rules for boiler designs are founded. But about plastic strength of materials we are just beginning to acquire knowledge. We do know that structures which ought to have failed many years ago seem destined to last forever. There are numerous known cases of steam boilers and no doubt thousands unknown cases in which the factor of safety has fallen far below that permissible by our standard code, and yet failure has not occurred.

This condition or result is attributed to plastic depreciation which causes the metals to acquire new physical properties.

Mathematicians treat materials as if they were perfectly elastic as glass in a semi-molten state, whereas mild steel is not only plastic, but has the wonderful property of remolding or reconstituting itself, if, and when overstrained.

It therefore follows, that, while the mathematical theories may be correct to a certain degree, they are evidently only correct up to the elastic limit. Consequently, there has not yet been laid a foundation for the mathematical treatment of plastic stresses, and the impression has gained ground that if the stresses in a material exceed the elastic limit, and therefore incalculable it must be considered as having failed.

Of course both metallurgists and mathematicians will in all probability take exceptions to the open or unqualified nature of this position. It is a well-known and generally accepted fact that all engineers try to keep well within the known elastic limits of materials they employ, and when greater strength is required they seek metals of even higher elastic limits so as to keep well below the danger point.

It is argued that in the above practice engineers may be plunging themselves into greater difficulties by surrendering the great value of plastic properties of materials with a low resisting power. Engineering knowledge on this feature, which have been amplified by fatigue experiments, leads to the conclusion that they have unknowingly been dealing with plastic stresses. If mild steel will not stand plastic stresses most engineering structures would have failed long ago. If it is safe to assume the foregoing conclusions may be used as a "yard stick," as it were, to measure steam boiler design with particular reference to strength of materials, it is obvious that our present factors of safety are unnecessarily too high. Consequently, if the premises are well taken and the reasoning sound, then the weight and thickness of material might be reduced without endangering the life of boilers.

In reaching the above conclusions, however the suggestion is made that any move made in the direction should be preceded with such experiments as will remove any element of doubt as to the advisability of reducing materially the present factor of safety and that attention should be given to working conditions.

No doubt a great deal of valuable information about boiler design could be secured by testing to destruction under working conditions with such variation of materials as to cover the points on which additional data may be desired. This is particularly true at the present time, when we are entering an era of much higher pressures, particularly in locomotives, and the only way we see of meeting these increased pressures is to augment or increase the resisting power of the material and increase its thickness.

If these suggestions and conclusions came from one without extended experience and authority in the field it would be quite easy to brush them aside, as rash, dangerous, or revolutionary, but coming as they do from a recognized authority for some thirty years in the field of steam engineering, and accompanied as they are with words of caution as to procedure, they are not only entitled to careful consideration, but cordial cooperation in further research along these lines.

The limitations as to wheel loads in the design of locomotives not only suggest, but make it imperative that we determine by trial, test, and such other methods of research as may be employed, in determining to what extent the above suggestions may be introduced in boiler design, without sacrificing known limits of safety.

Friction, Versus the Volume of Steam Used in Practical Engineering

The above caption, while broad in its scope or application, can be narrowed down to any problem within the range of applied mechanics where a prime mover is employed as a source of initial power.

When considered in connection with railway operation it embraces the unit costs and results therefrom of all motive power, rolling stock, shop machinery tools and other appliances or devices, the prime movers for which either directly or indirectly employ steam power.

We are so accustomed to consider equal numbers of even value that we are sometimes led into error of our own creation.

Ordinarily, if an offer or proposition were made which embraced the option of a saving of ten per cent by a reduction in friction, or twenty per cent saving in steam used, the twenty per cent would be chosen simply because twenty per cent is twice ten per cent. If a careful study be made, it might be found that the ten per cent reduction in friction would bring much greater returns than the 20 per cent in volume of steam used, and in the last analysis the greater potential and real money value.

Some of the reasons for the above are that in reducing the element of friction 10 per cent there will automatically follow other unspecified beneficial features that will materially add to the sum total of economies.

Important factors resulting from a reduction in friction are in savings on maintenance costs, in attendance, adjustments and constant repairs, and a great saving effected in loss of time and expenses incident to delays.

The average designer and user or operator is prone to conclude that with generous wearing surfaces, properly fitted and well lubricated, there is nothing more necessary to secure freedom from friction, but, the weak point in this doctrine is that it fails to take into account the factor of alignment, and absolute alignment implies many considerations, some of which never occur to designers of machinery who consider their products examples of perfection.

One of the reasons for this fallacious theory lies in the fact that many machines which leave the drawing room in a state of perfection seldom ever measure up to that state or condition in actual service, and while this is more applicable to the motive power and rolling stock of a railway it is nevertheless true with respect to shop tools and machinery and other stationary installations.

A close study of all factors in the question of design, and particularly in the practical operation or use of all machines, tools or other units in which the element of friction enters, will no doubt disclose the fact that there are great wastes of the energy used to propel or operate a machine. Add to this the expense of the attendance and repairs, loss of time caused by delay, and the loss of capacity, and when it is all summed up the great opportunity to effect marked economies through the channel of actual reduction of friction will be apparent. It is now exacting an unnecessarily stupendous overhead burden on most all prime movers.

Service of Railroads Is Indispensable

Steam railroads are, and so far as now can be discerned will remain, the backbone of the national transportation system, Commissioner Esch states in his recent report advocating the regulation of the motor bus transportation which has reached maturity and deserves to be put on an equal basis with steam and electric railways under federal regulation. While the report holds that it is not yet necessary to regulate motor truck lines carrying freight or express, it indicates that experience may show this to be desirable later on.

In discussing the vital place which the railroads occupy in our modern civilization, Commissioner Esch says:

"They alone can be relied upon for mass transportation and long-distance hauls of passengers and goods. On December 31, 1926, the steam railroads of the country owned 249,138 miles of main line road; 66,847 locomotives; 56,855 passenger train cars in service; and 2,403,967 freight train cars.

"In 1926 the freight capacity of the steam railroads was 111,450,000 tons and that of motor trucks about 3,066,000 tons. Steam and electric railways had a potential passenger-carrying capacity of 6,600,000. Automobiles, private and common carrier, had a passenger-carrying capacity of about 70,390,000 passengers.

"In 1924 suburban trains carrying commuters between New Jersey points and New York City carried 246,450,000 passengers. In 24 hours the traffic one way was about 385,000 passengers.

"In 1925 the total freight ton-mileage of the steam railroads was reported as 414,139,835,000 ton-miles; ton-mileage of motor trucks as estimated by the Bureau of Public Roads was 16,355,526,667 ton-miles produced over city streets and rural highways.

"If one-half of this ton-mileage was produced on rural highways it would represent about 1.9 per cent of the ton-mileage produced by the railroads in 1925."

Electrifying a Narrow-Gauge Railroad

The application of electric operation to a heavy-traffic, rapid-transit railroad is exemplified by the complete electrification, now in progress, of the Boston, Revere Beach & Lynn Railroad. This railroad, of the narrow-gauge type (three feet), connects East Boston and Lynn, Mass. —a distance of nine miles—with a branch reaching the town of Winthrop.

The line is double track throughout. During rush periods six-car trains are operated on 10-minute schedules on each division. The company also operates four large and modern ferryboats between East Boston and Rowe's Wharf on Atlantic Avenue, Boston, connecting with all trains.

Electric equipment for the change-over will be furnished by the General Electric Company. Sixty two-motor traction equipments will be installed on the passenger cars, and four-motor equipments will drive the work cars. Three electric substations will supply the power necessary for the operation of the cars, delivering it through the medium of an overhead distribution system.

Each of the passenger car equipments will consist of two 60-horsepower, 600-volt motors with lightweight multiple control. Each work car will be equipped with four motors of the same type but with platform type control. Electric headlights will be used on all cars. Air brake equipment will be of the double-end, electro pneumatic type. The electric equipment will be installed on the present coaches and the work will be done in the owner's shops. Meanwhile, the use of electricity will be extended to the waiting rooms where electric turnstiles will be placed in service without waiting for electric train operation.

Two of the electric substations will be fully automatic, one containing a 1,000-kilowatt synchronous converter and the other, two synchronous converters of the same size. The third substation will be of the portable type, carrying a 1,000-kilowatt, manually-controlled converter.

Power will be purchased from local power companies and distribution will be made over a 600-volt catenary line. Simple, direct suspension will be used in the yards and sidings.

Electrification will replace 26 narrow-gauge steam locomotives now in use. Under the direction of the engineering and management organization of Hemple and Wells, numerous other improvements will be made, including the remodeling of the stations and the modernization of all equipment.

Hydro-Pneumatic Pit Jacks and Drop Pit Tables

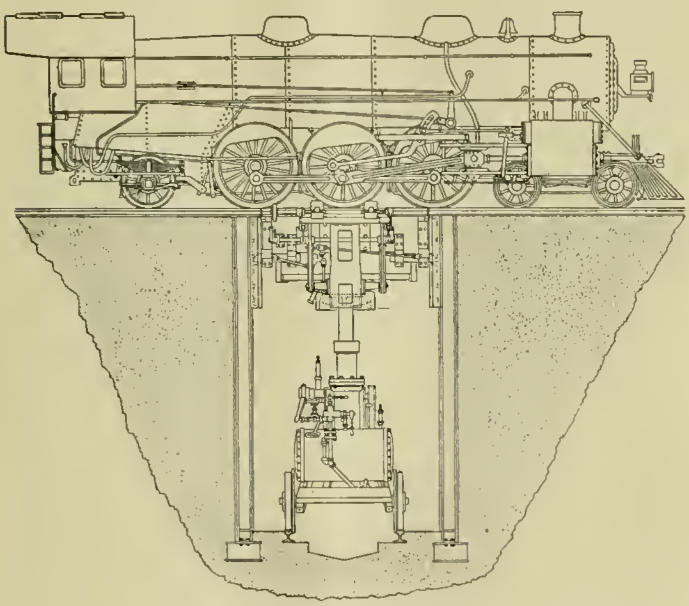
Performance Record in the Shops of an Eastern Railway

Demonstration of the need for a safer and more economical equipment than ordinary jacks for handling locomotive truck and driver repairs on one of the larger Eastern railways resulted in the installation in the latter part of 1924 of three hydro-pneumatic pit jacks and drop pit tables. The equipment was furnished by the Watson-Stillman Company, and their performance record is made available from a survey made by the A. C. Nielson Co., Chicago.

Two of the three jacks have a lifting capacity of 50 tons and the third, 30 tons. They travel in pits at right angles to four shop tracks, on rails 12 ft. below the top of shop track rails, and each serves two tracks, delivering drivers or trucks to short intermediate wheel tracks.

An air motor supplied with air at from 100 to 110 lb. pressure drives a plunger type hydraulic pump through a chain drive, and furnishes power for traversing the tracks.

Water is used in the ram, with alcohol added in winter. A simple system of valves and levers permits control of the jack by one man from one position. The ram is raised



Diagramatic Illustration Showing Pit Construction with Jack and Table in Place for Handling Locomotive Drive Wheels

to position quickly by admitting air to the water reservoir and forcing water into the cylinder. The hydraulic pump is then thrown into action for lifting.

Drop Pit Tables

The six tables are of sizes to accommodate three classes of equipment, the lengths being 10 ft. 6 in. and 8 ft. 6 in. for one 50-ton unit, 5 ft. 6 in. each for the second and 4 ft. 6 in. for the small unit.

Machined guides are provided on the pit walls, giving four points of support, and to which the tables may be locked when acting only to bridge the pit.

In addition to the saving in labor and locomotive time which will be covered in later paragraphs, these jacks have made dropping operations safe. The chance for accident, always present with jaw type jacks, has been reduced to a minimum by making the table of cast steel and providing sufficient points of support.

In Table A are given the costs of operating one of the 50-ton jacks and two tables serving two tracks. Depreciation is figured on the basis of a 10-year life on jack and other depreciating items and of a 20-year life on the more permanent investment in pit and trackage. With average interest at 6 per cent the fixed charge per average day is $3.31. Periodical maintenance costs are itemized, in accordance with the actual program followed and an estimated allowance is made for miscellaneous repairs, these amounting to $0.23 a day. None of the parts on any of the jacks have broken and the only parts replaced due to wear are bearing bushings. Considering that the jacks are in service for 16 hours on many days, this is a satisfactory record. Operating costs include oiling, alcohol for winter use, and compressed air. The latter is not measured but is estimated to be not over $0.50 a day, based upon the proportion of total shop requirement used in the intermittent operation of the jacks. The daily operating cost is thus $0.64.

The total of these daily costs, based on 310 days of operation per year, is $4.18 per day. For an average 8-hour day the cost per hour is $0.53.

Table A—Operating Cost of One 50-Ton Hydro-Pneumatic Pit Jack and Drop Pit Tables, Serving Two Pits

Fixed Charges:		
Depreciation on cost plus installation expense—		
$6,800 ÷ 10-year life	$ 680.00	
$1,500 ÷ 20-year life	75.00	
*Average interest @ 6%—		
11/10 × $6,800 × .06/2	224.40	
21/20 × $1,500 × .06/2	47.25	
Total annual and daily fixed charge	$1,026.65	$3.31
Maintenance and Repair:		
Grinding air motor valves and applying new bushings every nine months—(machinist and helper)—		
6 hr. @ $1.29 ÷ ¾ year	$ 10.32	
Material	3.00	
Grinding in pump valves every 3 months—		
Machinist—2 hr. @ $.76 ÷ ¼ year	6.08	
Miscellaneous repair allowance	50.00	
Total per year and per day	$69.40	$0.23
Operating Expense:		
Oiling and Inspection—		
Machinist—1 hr. × 52 wk. @ $.76	$ 39.52	
¾ gal. oil × 12 mo. @ $.25	2.25	
⅔ lb. grease × 12 mo. @ $.30	2.40	
Alcohol to prevent freezing in winter	.70	
Compressed air—estimated—$.50 × 310 days	155.00	
Total per year and per day	$ 199.87	$0.64
Total Cost of Operating Jack and Tables:		
Per year	$1,295.92	
Per day—(310 operating days)		$4.18
Per hour—(8-hr. day)		.53

*Allowing for interest earned by depreciation reserve.

Power Handled

Dropping operations are accomplished with the jacks on the locomotives of the Pacific, Mohawk, Mikado, Consolidation and 8-wheel switching types. Front truck wheels, drivers and trailers as well as tender wheels are replaced. With the 50-ton jack having a 10 ft. 6 in. table, a complete front truck with both pairs of wheels can be removed in one operation. Four-wheel tender trucks are similarly handled. Some of the newer tenders have three pairs of wheels per truck, requiring two operations.

With three-cylinder locomotives it is almost out of the question to try and replace the front and main driving wheels with the ordinary air operated jaw jacks. There is no point of support where the old type jacks may be applied and the present jacks are almost a necessity.

Typical Handling Methods on Plain Trailer Wheels

In removing and replacing a pair of plain trailer wheels the procedure is as follows: The locomotive is run into the roundhouse and the trailers to be removed spotted over a section of depressed rail. The engine is blocked up between the back driving box and the frame to remove the weight from the wheels, and all necessary pins are removed. The engine is then spotted so the wheels to be removed are on the table, acting as a bridge. The jack is then brought up, the table raised so that the track section is about 2 inches above the main track level, the trailer frame is chained to the locomotive, and the jack is lowered, carrying with it a pair of trailer wheels. The table is then run out, and the wheels placed on another track. A reverse procedure is followed in replacing a set of new or repaired trailer wheels.

Table B—Costs and Savings On Typical Jobs

To remove and replace two pairs of wheels on tender truck—	
Hydro-pneumatic pit jack—4½ hr. @ $.53	$ 2.39
Machinist and helper—4½ hr. @ $1.29	5.81
Total	$ 8.20
To remove and replace pair of 69-in. main drivers on L-1 or L-2 Locomotive including knuckle pins, rods, drop binders, shoes and wedges—	
Hydro-pneumatic pit jack—4 hr. @ $.53	$ 2.12
2 machinists and helper—4 hr. @ $2.05	8.20
Total	$10.32
Labor cost with air-operated jaw jacks (from data at other yards of this company)—	
2 machinists and helper—8 hr. @ $2.05	$16.40
Reduction in time	50%
Reduction in labor cost	$ 8.20
To remove a complete front truck with 2 pairs of wheels, when renewing engine truck frame or a set of cylinder bolts on Mikado or Pacific type engines—	
Hydro-pneumatic pit jack—1½ hr. @ $.53	$ 0.80
Machinist and helper—1½ hr. @ $1.29	1.94
Total	$ 2.74
Labor cost with 2 ordinary 75-ton jacks—	
Machinist and helper—5 hr. @ $1.29	$ 6.45
Reduction in time	70%
Reduction in labor cost	$ 4.51

Two machinists and a helper can make the complete change with plain trailer wheels in 4 hours.

Another job on which the hydro-pneumatic jacks have proved to be particularly valuable is in replacing booster type trailer wheels, which were difficult to handle with ordinary jaw jacks. The booster crank case and fittings must first be removed and with the jaw jacks there were few points of support. Now, the entire table is beneath and makes the job of removing the various members much simpler. The job takes a total of about 7½ hours.

Savings in Labor

Some of the savings effected by the jacks are given in Table B. The time now required to remove and replace a pair of 69-in. main drivers on Mikado type locomotives, including the time to take off knuckle pins, rods, binders, shoes, and wedges, is 4 hours for 2 machinists and a helper. The total cost for the job is $10.32. From data at other yards of this company, the time required by the ordinary method, using jaw jacks, is 8 hours with the same number of men. The saving of 12 man hours is a reduction of 50 per cent. In addition to the saving of $8.20 in labor, there is the saving of 4 hours in locomotive time.

The time required to remove a complete 4-wheel front truck on either the Mohawk of Pacific type engine, for the purpose of renewing the engine truck frame or to put in a set of new cylinder bolts, is only 1½ hours for a machinist and a helper, employing the new jack. The cost of this job, including labor and the machine charges for the jack is $2.74. From information obtained from other roundhouses, the usual method would require two 75-ton jacks and five hours for machinist and helper. The saving of 7 man hours is a reduction of 70 per cent and a labor saving of $4.51.

No records are available from which the annual savings may be evaluated. On the operation mentioned in the preceding paragraph, a labor saving of $4.51 is effected in 1½ hours. In removing 69-in. drivers a labor saving of $8.20 is effected in 4 hours. These show hourly labor savings of $3.01 and $2.05.

Since the total daily cost of one jack with tables is only $4.18, the equipment fully pays for itself if used less than two hours a day at the rates of labor saving shown on these two jobs. Since the jacks are in use for 16 hours on many days, the savings are manifestly large.

Locomotive Performance on the Boston & Albany

By Arthur W. Curran

In a previous article of this series, something was said of the motive power history of the Boston and Albany during the past 25 years. Since then, reasons for further comment have developed.

Many readers of RAILWAY AND LOCOMOTIVE ENGINEERING must be familiar with Mr. Warner's articles in the quarterly magazine which is published by the Baldwin Locomotive Works. Very naturally, these articles are concerned mainly with railroads whose motive power is chiefly of Baldwin build.

Since the American Locomotive Company has not attempted anything of the sort in regard to its well-known customers, perhaps a few notes about them may be of interest at this time.

As its name indicates, the Boston and Albany connects the metropolis of New England with the capital of New York; the distance being slightly over 200 miles. In addition, there is a loop line—or "circuit"—known as the

Highland Branch, which serves a number of the suburbs of Boston between Brookline Junction and Riverside, via Newton Highlands.

Other branches are the Grand Junction, Newton Lower Falls, Milford, Saxonville, Millbury, Webster, Spencer, North Brookfield, Ware River, Athol, Hudson, and North Adams.

The Selkirk Branch, between Riverville and Tower SM, serves the Smith Memorial Bridge over the Hudson River, which gives access to the Selkirk Yard.

Contrary to what some persons might suppose, the B. & A. is by no means as flat as the proverbial pancake. Grades and curves are numerous; many of them being where the stranger would least expect to find them!

Most people have heard of the Berkshire Hills, and enginemen would expect to "drop her down in the corner" by way of salute to their prowess. Not so many, however, have heard of Charlton—which can bring some engines to a "stand"—and certain others which will "get you if you don't watch out!"

Over this rather difficult road, a through passenger and freight business of considerable volume is moved with great reliability; often in the face of very trying conditions. Most of the main line between Boston and Framingham has four tracks, arranged in pairs; west bound express and east-bound express, west-bound local and east-bound local. By this method, the slowing down of through trains by locals is prevented.

As, however, certain of the through trains stop at Newtonville—where there is an express platform on the north side of the right-of-way—it is necessary for west-bound expresses to stop outside the station whenever an east-bound express is discharging passengers across its path. Inasmuch as the tracks are in a cut at this point—and for some distance in either direction—nothing can be done except to arrange schedules so that such delays to fast trains will not occur, as a general rule.

Framingham calls for greatly reduced speed; so that even non-stop trains cannot get through there very quickly. All things considered, the road presents some very interesting problems from an operating point of view.

With regard to motive power: It was explained in the article already mentioned that, for a number of years, the B. & A. had to get along with some rather small engines, albeit good ones.

It was in 1925 that a group of five new engines of the Pacific type, known as Class K-6-a, and built at the Brooks Works of the American Locomotive Company, were placed in service on the road. These carried the road numbers 590-594, and were assigned to the best passenger trains. No. 590 is shown with the B. & A. Twentieth Century Limited (No. 25) in an accompanying photograph. The cylinders of these engines are 26 x 28 inches, drivers 75 inches in diameter, and weight, without tender, 298,000 lbs. They are equipped with modern accessories of proven value; but their great advance over previous designs for the B. & A. is due to the provision of a large boiler and firebox which, in turn, make possible the use of large cylinders. In general, the design is a good job, with ample speed for the level stretches and liberal capacity for hard, uphill work.

These engines were followed, in 1926, by another group of five, Nos. 595-599, known as Class K-6-b, and built at the Schenectady Works of the American Locomotive Company. Dimensions are the same, but the later engines are slightly modified in details. For example, whereas the Brooks engines carry their air-brake pumps on smokebox front, the Schenectady engines carry theirs in a housing just back of pilot-beam. The Schenectady engines also have piping, near cab, housed over. Otherwise, the two classes are much alike.

Between Boston and Worcester, No. 25 (the "Century") runs rather smartly, covering the 44.33 miles in 64 minutes, including a stop at Trinity Place—a mile and a quarter from South Station—careful running through several places, and the bad slowdown for Framingham.

The 54 miles between Worcester and Springfield are covered in 73 minutes. There is no intermediate stop, but on this stretch one is greeted by Charlton!

The 52.26 miles between Springfield and Pittsfield are very fine indeed; and, accordingly, require 92 minutes!

From Pittsfield to Albany the distance is approximately 50 miles and the time 70 minutes. This latter is a very good performance, considering the nature of the country!

Engines are changed at Springfield, east of which is the Boston Division and west thereof the Albany Division.

First of the K-6 Class Engines No. 590 at Newton, Mass.

No. 39 (North Shore Limited) also does very well between Boston and Worcester, making the run in 67 minutes. She stops at Framingham, and the "consist" is usually two or three cars greater than No. 25.

The Worcester-Springfield run is made by No. 39 in 78 minutes, but she stops at Palmer.

Springfield-Pittsfield requires 102 minutes, but she stops at Westfield.

Pittsfield-Albany accounts for 78 minutes, but she stops at Chatham (New York).

No. 11 (Southwestern Limited) and No. 13 (Wolverine) are, also, very smart over this difficult road.

No. 21 (Cleveland Limited) is almost as fast.

No. 37 (Buffalo Express) is very smart between Boston and Worcester, but makes more stops west of that point than the other good trains.

No. 43 (New York State Express) is in about the same class.

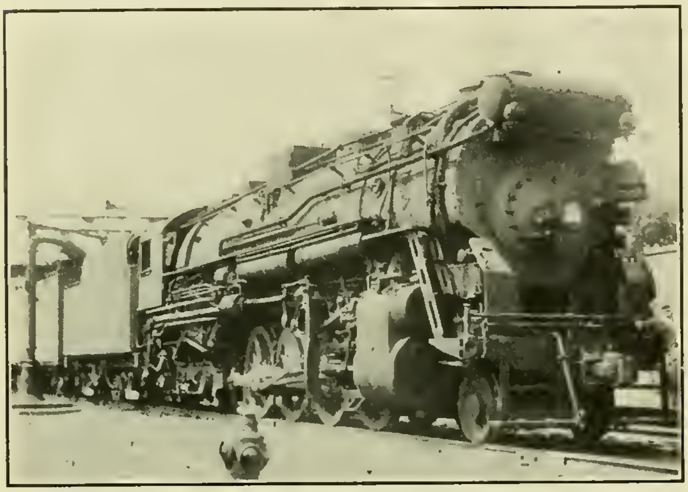
In addition to these trains, there are a number of local expresses which hum right along on the good stretches. In fact, the stranger who, for the first time, sees one of these trains pass a way-station, receives a decided surprise!

Finally, there are the Boston-New York expresses which are handled between Boston and Springfield by the B. & A., and between Springfield and New York by the New York, New Haven & Hartford. These are very heavy trains, and provide a good and reliable service at a very satisfactory rate of speed and at fair prices to passengers. All stop at Newtonville, and thereby save residents of the vicinity the bother of going to Boston to get a New York train. It will be seen that the B. & A. is a busy road and that its operating problems, by that very fact, are much increased. Yet, the road enjoys the reputation of "getting you there and back," even under climatic conditions which do not make for easy railroading.

With reference to freight service: Up to about ten years ago, much of this traffic was handled by Consolidation engines of classes that were developed by the New York Central. Some Mikado engines of similar origin were in service, also.

When the later Mikado engines of the class introduced on the Michigan Central appeared in greater numbers, the B. & A. got some of them. These are very good engines.

But the B. & A. likes its Berkshire (2-8-4) type best of all. One of these, No. 1432, is shown in an accompanying photograph. Built by the Lima Locomotive Works, these engines are now famous as the precursors of the new era in freight motive power. As the reader is, doubtless, familiar with the characteristics of these engines, it is not necessary to set them forth here. Suffice it to say that they are meeting all expectations, and that they have attracted the favorable attention of various other roads.



New 2-8-4 Class Engine 1432 Taking Water at Palmer, Mass.

It is true that some western roads meet some very severe operating conditions in the form of grades and curves; but their traffic density is not so great as what is found on eastern roads, nor are their speed requirements so exacting.

In conclusion, my acknowledgments are due to Mr. Horace W. Pontin for the excellent photographs with which this article is illustrated.

A Power Plant on Wheels

New gasoline engines which can be removed from trucks, buses or even railway locomotives, and replaced with new ones as easily as an automobilist changes tires, were explained and demonstrated to the New York Electrical Society by William B. Jupp, engineer of automotive rail equipment of Mack Trucks, Inc., in addressing the Society on "Power Plants on Wheels."

The "power plant on wheels," Mr. Jupp explained, is a complete power unit consisting of gasoline engine and electric generator, to be used with an electric drive to furnish power for virtually any kind of transportation. It is unique in that a single base contains all the power equipment and accessories except the gasoline tank, the radiators and such electric motors as may be used to drive the axles.

Power can be supplied to these driven motors at a cost of 3c. to 5c. per kilowatt hour. When applied to buses, the power plant is mounted crosswise of the vehicle in the rear, eliminating the customary hood. Applied to street cars, the power plant is mounted similarly across the back of the car. Such cars can reduce greatly the cost of operation, since the power house and trolley wires are eliminated. This is expected, Mr. Jupp said, to restore life to the suburban trolley which can be operated by these units at about two-thirds of the cost per passenger seat of the cost of buses. This cheapening is due to the increased size of vehicle which can be moved on rails with the same power, as compared with movement on rubber tires.

An important application is expected to be to railway transportation. More than one power unit can be used, ranging from what seems to be a single day-coach moving along the rails without the help of a locomotive, to a six-car commuter train in which the cars at each end of the train contain power units. By means of a novel system of remote control, these units can be operated by an engineer at either end of the train.

Such railway equipment operates at great savings over trains drawn by locomotives. For a sixty-passenger single-engine car the cost will be 25c. to 30c. per mile; for a two-car train the cost is 35c. to 45c. per mile; for a six-car train it is $1.00 per mile. These are to be compared with locomotive costs of from $1.00 to $1.50 per mile. There has been devised a unit called "The Amalgamated Train" containing in one car a locomotive, a baggage space, a smoking compartment, a passenger compartment and even, if desired, a mail compartment.

Actual locomotives driven by these unit power plants are expected also, to replace steam locomotives for handling freight on branch lines or railways of relatively small traffic, the "Amalgamated Train" or other rail car being used for passengers. By thus eliminating necessity for water towers, ash pits, coal pockets, roundhouses, repair facilities, etc., many railway branches now profitless or inoperative, may be converted, Mr. Jupp believes, into profitable enterprises.

The nuisance of smoke from steam switching engines now attracting so much attention in all cities, will be eliminated, Mr. Jupp predicted, by the widespread use of smokeless gasoline power plants of the type described. Even in ship propulsion these unit power plants promise surprising utility. No hold space is necessary for engines, except the small space for a motor on the propeller shaft. Thus ships may be more cheaply built, and will have larger cargo carrying space.

The use of removable unit power plants, each one the duplicate of every other one, provides for production in quantity by modern factory methods, as well as for easy removal and repair, without laying up the vehicle while such repairs go on. Quantity production of the units will mean, Mr. Jupp said, low initial cost, low cost of replacement parts, and quick and widespread repair service. More important still, it means increased earning power of transport equipment due to the availability of the vehicle while the power plant units are being inspected or repaired.

It is impossible to predict, Mr. Jupp concluded, all of the important modifications of present day power practice, in transportation and elsewhere, which may be expected to result from the new development.

The development in the various fields to which this new type of prime mover is applicable is wide, variable and rapidly changing in order to keep up with the great strides made in engineering and transportation generally. It would indeed be difficult to predict with any degree of accuracy the extent to which such a unit, as described by Mr. Jupp, may be advantageously applied.

Heat Treating Methods and Equipment for Railroad Shops

Committee Report to the American Railway Tool Foremen's Association

The first point to take into consideration before making any recommendations and one on which the entire subject depends is the method of handling these tools on the various roads. We feel and recommend that in order to install the proper equipment and eliminate, as far as possible, failures due to incorrect heat treatment, the handling of all tools requiring heat treatment should be taken care of at a central point, as far as consistently possible with the needs of the system, or failing this, should be handled at as few points as can be arranged, due consideration being given to necessity of handling to and from this point and to the needs of the individual stations. This being done, it is then possible to install proper methods, which would be entirely impracticable as a recommendation for installing at all or any small points.

For the proper discussion of the subject we have divided it into three subdivisions, as follows:

1st. Manufacture of and repairs to chisels, caulking tools, and similar tools.

2nd. Manufacture of and repairs to High Speed Machine Tools.

3rd. Manufacture of and repairs to reamers, taps, rivet sets, etc.

Taking these up in order, the type of heat treating equipment to be recommended depends on the different practices on these particular items.

1st. The question of individual practice in purchasing finished chisels, finished blanks to be worked into a chisel or other tools or manufacturing them from purchased stock is one which we feel should be left to each road, although we do feel that we should bring up the thought that there are several concerns that are investigating this matter very thoroughly and it is undoubtedly true that these people can go into researches that are impossible for each road to conduct and we should keep in touch with their results so as to make proper recommendations to our officials when developments would indicate that it would effect an economy to purchase these tools.

It is self-evident that if a workman is kept on one job that he must necessarily become more proficient at this particular phase of his work and this is also true of the treater. It is not fair nor to be expected that a blacksmith who spends 95 per cent of his time on ordinary locomotive or car repairs shall, when he is given a chisel or machine tools to forge and harden and temper, produce as uniform or as good results as a properly trained heat treater who devotes his time to it exclusively. Nor is it to be hoped that where this work is handled by these men that there will be any uniformity of product or that any very large percentage of the service possible from a particular piece of steel will be realized. It is quite true that he might get by, but there is a very great difference between getting by and real efficiency of tools and this is not only in the tool itself but in the use of it. A tool properly heat-treated which will give good service before being returned to the tool room, pays for the cost of proper heat treating several times over.

It is also true that where the work is centralized and the heat treatment is to be changed for any reason it requires a minimum of expense and education to accomplish the change.

It is also true that a good many of the tool steel manuacturers have alloy chisel steels on the market and some roads have given these serious consideration. The principal drawback to their use has been that it is not possible to give them the proper treatment unless equipped with regular heat treatment furnaces. However, it is true that this particular matter is being worked on so that these steels can be heat-treated in the same ranges and same conditions as straight carbon tool steels and is worthy of further study.

The first consideration to be given in the treatment of chisels (and for the purpose of this discussion and to avoid wearisome repetition the word chiles will be used to denote calking tools and all other tools of similar nature), is the forging. This is the point that causes more failures than any other as, if this is not properly done, then all subsequent processes, however carefully they may be done are utterly useless. And, of course, a decidedly important factor is the heat treatment the steels have received before being worked in the shops. It is absolutely unfair to the heat treater to give him an inferior piece of steel and expect him to treat it and get good results. And here it might not be amiss to call attention to the necessity of purchasing such material of sufficient uniformity so that when a proper and uniform heat treatment will yield tools which will give comparatively uniform service. While analysis of steels will serve as a basis on which to start, the fact remains that carbon steels can be manufactured in open hearth furnaces to meet the average analysis and it cannot be expected that tools of uniform and good quality can be manufactured from these steels. Therefore the first essential for successful heat treatment of tools is the proper selection of steels. The next essential is that the carbon content be known so that the proper quenching and drawing temperatures may be known. These being known the forging is the first item in the treatment.

It is essential in forging that the blanks be preheated sufficiently to take out the strain before being placed in the forging furnace, particularly where the blanks are subject to severe cold. They should then be heated back sufficiently far from the end to note above 1700°, or an orange heat, care being taken to see that the heating is not done too rapidly and also that the heat has penetrated entirely through the steel or in other words to see that the surface is not being worked at one temperature and the core at another. This is not to be construed, however, into favoring soaking after the tools have reached the proper heat as this is as bad as not heating sufficiently. They then should be forged as rapidly as possible, finishing the forging at a dark red heat with light blows in order to secure the utmost refinement of grain. The tools should then be reheated to approximately 1450° or bright cherry to take out working strains and allowed to cool. This should be done preferable in lime if possible, as this puts the steel in the best possible condition for the hardening and tempering operations.

Suggestions on Preheating

For hardening, the tools should be preheated to at least 300 or 400 degrees by placing on top of furnace or hot plate and then placed in a semi-muffle type furnace with a reducing flame and heated to between 1425 and 1475 degrees according to the carbon content and size, the lower figure usually being the most desirable for chisels and similar tools, or they can be heated in a lead bath which can be held to the exact temperature desired and eliminates oxidation. The tools are now quenched as rapidly as possible in order to prevent any scale accumulation, which gives unequal hardening and any drop in temperature before quenching. The quenching should not be done on a line, that is, the tools should be moved up and down so that there will not be any distinct line between the hardened and softer sections but a gradually decreasing hardness. Water kept between 70 and 100 degrees is preferable for the quenching medium for these tools. The tools should then be drawn either in a bath or by the color method to suit the particular conditions the tool is to encounter.

For redressing these tools at small points the same practices can be followed out without great expense, the ordinary forge fire being fitted with fire brick surrounding the fire pot with suitable openings in the front and boiler plate cover placed on the fire brick. This gives excellent service and very good results can be obtained from same. One type is used on the C. M. & St. P. but any simple design can be used to good advantage provided that the principle of keeping excess air from the tools and the other points enumerated are followed out.

For equipment for the central point any type of semi-muffle furnace or lead bath will give good results and should be equipped with pyrometers which should be checked frequently. The quenching tank should be of sufficient size so that the temperature will not rise too much as this gives an uneven hardening. Some form of cooling system can be installed at little expense if necessary, for larger stations either water in coils or a jacket around the tank or air to agitate the water or any combination of the same.

2nd. Manufacture and repairs to High Speed Machine Tools.

The same conditions that make for centralized manufacture of carbon tools are even more imperative for the proper manufacture of high speed tools and these should be centralized at as few points as possible as the increased life and efficiency of perfectly treated tools more than offsets any difficulties which might occur due to this practice.

High speed tools should be heated through thoroughly before being placed in the forging fire as the alloys which give this steel their properties likewise render it exceedingly dense and slow to react to heat. The fire should be free from excess air and have a deep bed of coke. The tools should be heated thoroughly on the end to be forged to a temperature of 2000 degrees or a light yellow and forged rapidly. If cooled below 1600 degrees or a dark orange, before forging is complete, it should be placed back in the fire and reheated, this being repeated as often as necessary to finish the tool. It should not be heated farther back than is necessary to shape the tool but far enough so that no work will be done on any portion below a bright cherry.

After the forging is complete the tool should be normalized, that is, brought to 1400 degrees and then cooled in the furnace or dry lime or ashes. It should then be heated through thoroughly, then placed in the fire and heated slowly to about 1600 degrees, then brought rapidly to 2350 degrees or a bright white heat and held there until the nose sweats freely and then cooled in a dry air blast or quenched in oil or a preheating furnace can be used to bring the tools to 1600 degrees and then placed in a high heat furnace held at 2500-2600 degrees and kept there until the nose sweats and then cooled.

The tools should then be drawn, preferably in a lead bath to 1075-1100 degrees, which materially increases their life, reduces breakage and relieves hardening strains. This should take about a half hour at the required temperature.

The preferred type of equipment for a central point is a double deck furnace, semi-muffle type with the waste gases from the high heat utilized in the preheat chamber. This is economical in heat and space and also desirable from a handling standpoint. A similar lead bath can be used to the one used for the carbon tools. If oil is used for quenching, a suitable tank with cooling arrangement must be installed and if air is used a separatcr should be used in the line immediately adjacent so that dry air is assured and a reservoir installed so that uniform volume is secured. The air is played directly on the nose of the tool. Drawing should take place before the tool cools entirely.

For dressing in small shops the forge previously described can be used to advantage, the drawing being done to color, but this is subject to more fluctuation in results.

3rd. Manufacture and repairs to reamers, taps, rivet sets, etc.

All special tools, whether carbon, alloy or high speed steel should be manufactured at one central point as there is no reason for any other practice such as obtains in the first two articles. Heat treatment, of course, is according to limits laid down and worked out to best advantage in your own shops. For this purpose the double deck furnace previously desirable is admirable, costs less than two furnaces, one for preheat and one for high heat, but of course, where the carbon tools are in excess, then for this purpose, one furnace should be provided for lower heats and one for higher heats.

Insofar as to the types of furnaces recommended this more or less depends on the locality of the shop as in different instances, electricity, gas or oil might be the cheaper medium to employ. It is undoubtedly true that for carbon steels, the electric furnace prevents oxidation and gives an easily adjustable, uniform heat, but for high heat up to a few years ago, the electric furnace was expensive, hard to maintain and not generally used nor recommended, nor is it used in the larger manufacturing plants today. However, in the last few years, electric furnaces have been brought on the market which seems to meet all objections thereto and should be thoroughly investigated.

A New Thought on the Origin of Coal

In the course of study of the formation of peat being conducted by the Bureau of Mines, samples of peat have been collected at various depths in Wisconsin peat bogs and are being analyzed to determine the rate of decay of various vegetable constituents such as woody matter and cellulose. The main question to be decided is whether wood (lignin) or cellulose, the principal constituents of plants, decay completely in the process of peat formation. If either decays completely, leaving no solid decomposition products, it can be concluded that the other is the original substance from which coal was formed. It is generally conceded that coal was formed from peat. Since the action of bacteria plays an important part in the decay of vegetable matter, a thorough investigation of this phase is now being made. It has been found that bacteria exist at all depths in the peat bogs but they are probably more or less dormant in the lower levels. It has been found further that where bacteria have become dormant their activity is quickly resumed when supplied with available nitrogen.

A Remodelled Mallet Type Locomotive

At the Sacramento shops of the Southern Pacific Company a Mallet type locomotive was recently remodelled into a four-cylinder simple engine. The engine was formerly an Articulated Compound Mallet Consolidation with high pressure cylinder 26-inch diameter by 30-inch stroke, and low pressure cylinders 40-inch diameter by 30-inch stroke, and had a tractive effort of 85,040 lbs.

As rebuilt, new cylinders of 22 by 30 inches were applied. The preheater was removed from the boiler and an extra course added giving the boiler greater heating surface. The heating surface was further increased by the application of a combustion chamber in front of the firebox. A type "E" superheater was applied; also a front-end throttle, which gives drier and hotter steam to the cylinders. A feed water heater and pump and mechanical lubricator were applied.

The cab fixtures were all re-arranged to give the engineman easier control of them, and more room in the cab. The capacity of the tender was increased from 9,800 gallons of water to 12,000 gallons. Oil capacity increased from 31,120 gallons to 37,710 gallons. A new truck of greater capacity and larger journals was applied to front of tender and a Bethlehem Auxiliary locomotive applied under rear of tender. This auxiliary locomotive develops a tractive power of approximately 14,400 lbs. The increase in tractive effort of engine from 85,040 to 90,940 lbs., together with the tractive effort of the auxiliary locomotive, gives the engine a combined tractive effort of 105,340 lbs.

The following figures gives an idea of the engine: Cylinders (4) 22-in. diameter by 30-in. stroke, all high pressure. Drivers 57 in. diameter. Steam pressure 210 lbs. Weight of engine on drivers, 401,000 lbs. Weight of tender loaded, 243,420 lbs. Weight of engine and tender, 644,420 lbs. Length of engine and tender, 104 ft., ½ in. Combined tractive effort engine and auxiliary locomotive, 105,340 lbs. Wheel base of engine, rigid, 15 feet. Wheel base of engine, total, 56 ft., 7 in. Wheel base of tender 15 ft., 1½ in. Wheel base engine and tender, 80 ft., 11 in.

This engine cannot now be called a Mallet, as that name refers to a system of compounding an articulated engine first proposed by Anatole Mallet, from whom it derives its name. This engine is now an articulated consolidation engine.

Perhaps this is the only engine of the type in existence. The Southern Pacific Company is rebuilding five other Mallets, as this type has proven quite satisfactory for freight service on mountainous lines.

2.1 Ounces of Coal Per Ton Mile

Class I railroads in 1927 attained the greatest efficiency in the use of fuel by road locomotives on record, according to complete reports for the year just filed by the railroads.

An average of 131 pounds of fuel was required in 1927 to haul 1,000 tons of freight and equipment, including locomotive and tender, a distance of one mile. This was the lowest average ever attained by the railroads since the compilation of these reports began in 1918, being a decrease of six pounds under the best previous record, established in 1926.

For every pound of coal or its equivalent used, the railroads in 1927 hauled 7.6 tons of freight and equipment one mile.

The means that for every 2.1 ounces of coal, the railroads, in view of the striking increase in efficiency, hauled an average of one ton of freight and equipment one mile.

Class I railroads in 1927 utilized for road locomotive fuel 95,459,840 tons of coal and 2,042,137,055 gallons of fuel oil. In each instance, a decrease was shown under 1926 due to the reduction in traffic handled.

Unit Costs of Switching Service

To the older generation of railway men the idea of continuing the use of horses as prime movers for switching service in railway yards or terminals in this day and age would be received with quite a few "grains of salt," while the younger generation would consider it as a joke.

It is therefore of interest to note that in a "Technical Essay" in one of our English contemporaries there appears quite an article on "Shunting Methods and Costs," in which the different systems of shunting or switching service, as we call it in this country, is dealt with under the following titles:

Capstans—Horses—Tractors with internal combustion engines such as used for road or agricultural purposes—Internal combustion shunting locomotive—Electric battery locomotive—light steam locomotives with reduced drive—Steam shunting locomotives of conventional design.

After quite a thorough discussion of the relative merits and costs of operation of the different methods of switching, the following conclusion as to economy of operation is reached with respect to the costs per hour for the motive power or prime mover under the different systems:

Horses	$1.92
Road Tractor	.95
Petrol or Gasoline Locomotive	.81
Light Steam Locomotive	.76

From the foregoing it would appear that while hay and oats is still used to some extent as fuel in railway operation, it is more expensive than the three others shown in comparison.

Brotherhoods Want Mechanical Firebox Doors

The Brotherhood of Locomotive Engineers and the Brotherhood of Locomotive Firemen and Enginemen have filed a complaint with the Interstate Commerce Commission asking that the commission adopt a rule requiring that all locomotives be equipped with mechanically operated firebox doors. In their complaint they state that the chief inspector of locomotives has recommended the adoption of such a rule and that the legislatures of several states including Georgia, Indiana, Iowa, Michigan, New York, Ohio and Wisconsin have passed laws requiring them and that some railroads have equipped a large number of their locomotives with such firebox doors.

America's Share of World Railway Mileage

The average miles of railway throughout the world per 10,000 population in the year 1925 numbered 4.2, according to an analysis just completed by the Bureau of Railway Economics. The report shows further that there was an average of 1.6 miles of railway for every 100 square miles throughout the world.

The total railway mileage throughout the world was 764,238 miles, of which the United States, including Alaska, had 250,900 miles. The total mileage in all of Europe was 238,867.

The entire North American continent had 316,644 miles of railway at the end of 1925, or 21.9 miles for every 10,000 population. The United States mileage amounts to an average of 23.6 miles of line for every 10,000 population. Canada had 40,093 miles, or an average of 42.8 miles for every 10,000 population.

Persia has the smallest amount of railway mileage per

10,000 population of any country in the world. Its average amounts to one-tenth of one mile. China comes next with .2 miles of line, and Nigeria is third with .6 miles.

The following table summarizes the outstanding facts of the railway mileage of the world:

Continent	Miles of line at end of year 1925	Area (sq. miles)	Population (Number)	Miles of line in 1925 per 100 square miles of area	Miles of line in 1925 per 10,000 population
North America	316,644	8,574,483	144,645,000	3.7	21.9
South America	56,884	7,367,109	69,911,000	0.8	8.1
Africa	37,481	9,448,308	112,382,000	0.4	3.3
Asia	84,252	16,303,292	1,007,315,000	0.5	0.8
Australia	30,110	3,092,087	7,695,000	1.0	39.1
Europe	238,867	4,244,251	472,894,000	5.6	5.1
Total—World	764,238	49,029,530	1,814,842,000	1.6	4.2

A Luxurious Club Car

A new type of club car, five of which have been recently put into service by the Chicago, Burlington & Quincy Railroad, provide comforts and conveniences as well as the interior finishing and appointments that rival those of the finest homes.

An idea of the richness of the car interiors, which are finished in real American walnut, can be gained from the illustration. Between each pair of windows is a panel of specially cut walnut veneer arranged in a diamond pattern. And over each window is a flowered design set in the walnut, the symmetrical and varied grain effects being brightened by soft side lights delicately shaded.

Interior View of New Club Car of the Chicago, Burlington & Quincy

In the center of each car, at either side of the aisle, are nooks set apart for those who wish to play cards. Partitions which separate these nooks from the rest of the car are of walnut and have cigar lighters mounted on them like the lighters on automobile instrument boards. Cushions and backs are softly upholstered in leather. In the rest of the car the furniture is overstuffed in a charming variety of design and color, the chairs being movable so that they can be placed where they will provide the utmost in relaxation and rest. Added value is given to the observation platform by enclosing it in glass, the type used being capable of letting in the sun's ultra violet or "health rays" which cannot come through ordinary glass.

A special lounge or parlor, richly finished like the main lounge, provided with the little comforts and conveniences that women crave, and set apart from the aisle with a high walnut grillwork that gives the parlor an air of exclusiveness and privacy all its own.

Railway Wage Advances Last Year

Wage advances last year granted to various classes of railway employes amounted to 40 million dollars, according to an estimate by the Bureau of Railway Economics. The Bureau's computation is contained in a recent analysis of the wages of employes and the hours worked during the year 1927.

During the first six months of 1927 the number of railway employes averaged nearly 1 per cent less than during the first half of 1926. Owing principally to the heavy decline in traffic during the last six months, the number of employes fell off more heavily, resulting in a reduction during the second half of the year of nearly 4 per cent under 1926.

The final result was that the average number employed throughout 1927 was 1,764,000, compared with 1,805,780 during 1926. This was a reduction of nearly 42,000, or about 2 per cent.

The aggregate compensation paid to employes during 1927 was below 1926, the comparative figures being $2,952,000,000 in 1927 and $2,990,000,000 in 1926. This was a decrease of about 1 per cent in number of employes.

It follows that the average compensation per employe was on a higher level in 1927 than during the previous year, just as the average annual compensation in 1926 was higher than in 1925, while that for 1925 was higher than in 1924. Progressive increases during the past four years brought the average for the year 1927 to approximately $1,673. The corresponding average for 1926 was $1,656, while that for 1925 was $1,640. In 1924 it was $1.613.

The number of hours worked showed a slight decline in 1927. The average per day in 1926 was 8.58 hours, while the corresponding average for 1927 was 8.53 hours. This indicates that the increased compensation received by the average railway employe in the year 1927 was not due to increased overtime work, or to any increase in the number of the hours of regular work per day, but was entirely the result of increased wage rates.

Had the same average compensation been received by the employes in 1927 as in 1926, the total payroll of the railways would have been approximately $30,000,000 less than it was. Bearing in mind the reduction in the average number of hours worked per day, it seems fair to conclude that increased wage rates were responsible for not less than $50,000,000 of the total wage bill of the railways in 1927, as compared with the corresponding wage rates of the previous year.

Reclamation Saves Millions a Year

The Class 1 railroads are saving more than 10 million dollars annually through the reclamation of various materials, and the repair of damage tools and parts which reach the scrap bins.

The following is a list of items compiled by the committee on reclamation of the International Railway General Foremen's Association, and shows a few of the things reclaimed by the railroads in reclamation work:

Angle and cut-out cocks—Axles
Babbitt metal—Boiler lagging
Bolts—Brake beams
Car forgings—Coil springs
Flues and tubes—Journal box packing and grease
Locomotive tools and equipment
Maintenance of way tools
Oil boxes—Pipe and pipe fittings
Rods—Roofing materials
Tinware, tools, valves, etc.

South African Railway Contracts

The development of the South African Railway system to meet the ever growing needs of the Union has led to an increasing demand for goods from other countries. In particular locomotives, rolling stock and steel are required. During the last fiscal year over $25,000,000 worth of railroad steel, rolling stock, etc., were imported, which clearly demonstrates the importance of this market to American manufacturers. What is more, there will never be in South Africa—as there is in New Zealand, for instance—a sentimental preference for British goods. Since last December orders totalling $5,301,065 are reported to have been placed in Germany, while the only order of any magnitude that has been placed in Great Britain was that obtained by the Metropolitan Carriage, Wagon and Finance Company, of Birmingham, for fifty coaches to cost $850,000, although it is understood that a contract for twenty-nine locomotives, amounting in round figures to about $1,000,000 has been allotted to the North British Locomotive Company. An illustration of the low quality of some European products was furnished by an incident which occurred not long ago when the railroad administration imported from Germany two heavy locomotives for trial use on the Cape Town-Johannesburg line. The first engine tried out failed to attain the pulling power claimed for it, and actually broke down. Tenders were recently invited for thirty-six locomotives of the "Mountain" type for branch line work, and the decision of the tender board will be awaited with interest. There is a growing field for American goods in South Africa, and our London correspondent suggests that no efforts should be spared to study the market.

Condition of Freight Cars and Motive Power

Freight cars in need of repair on February 15 totaled 136,346 or six per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was an increase of 231 cars above the number reported on February 1, at which time there were 136,115 or six per cent.

Freight cars in need of heavy repairs on February 15 totaled 96,338 or 4.3 per cent, a decrease of 356 compared with February 1, while freight cars in need of light repairs totaled 40,008 or 1.7 per cent, an increase of 587 compared with February 1.

Locomotives in need of repair on the Class I railroads of this country on February 15 totaled 9,349 or 15.5 per cent of the number on line, according to reports just filed by the carriers with the Car Service Division of the American Railway Association.

This was an increase of 616 locomotives compared with the number in need of such repairs on February 1, at which time there were 8,733 or 14.5 per cent.

Locomotives in need of classified repairs on February 15 totaled 5,040 or 8.4 per cent, an increase of 279 compared with February 1, while 4,309 or 7.1 per cent were in need of running repairs, an increase of 337 compared with the number in need of such repairs on February 1.

Equipment Installed in the First Quarter of 1928

Class I railroads in the first three months this year installed 465 locomotives, according to reports filed by the carriers with the Car Service Division of the American Railway Association. Compared with the corresponding period last year, this was an increase of 18 locomotives but a decrease of 105 compared with the corresponding period in 1926.

For the month of March alone, the railroads placed in service 140 locomotives compared with 142 in March the year before.

Locomotives on order on April 1 this year totaled 137 compared with 244 on the same date last year.

Freight cars installed in service in the first three months in 1928 totaled 10,064 compared with 15,796 for the same period in 1927 and 21,363 for the same period in 1926. Freight cars installed in March this year totaled 4,032 compared with 5,175 in March, 1927.

The railroads on April 1 had 25,248 freight cars on order compared with 27,255 on the same date last year and 49,524 on the same date in 1926.

These figures as to freight cars and locomotives include new and leased equipment.

Notes on Domestic Railroads

Locomotives

The Canadian Pacific Railway is inquiring for 25 Mikado type locomotives.

The Akron, Canton & Youngstown Railway has ordered two Mikado type locomotives from the Lima Locomotive Works.

The Cleveland Union Terminals Company is inquiring for twenty-five 150-ton electric locomotives.

The Southern Pacific System has ordered 3 Pacific type locomotives from the Baldwin Locomotive Works.

The Atchison, Topeka & Santa Fe Railway has ordered 15 locomotive tenders from the Baldwin Locomotive Works.

The Erie Railroad is inquiring for 35, 2-8-4 type locomotives and 1 oil-electric locomotive.

The Chicago, St. Paul, Minneapolis & Omaha Railway has ordered 8 switching locomotives from the Baldwin Locomotive Works.

The Canadian Pacific Railway has ordered 25 Mikado type locomotives from the American Locomotive Company through the Montreal Locomotive Works, Ltd.

The Southern Pacific System has ordered 10 Mallet 2-8-8-2 type locomotives from the Baldwin Locomotive Works.

The Dominion Coal Company has ordered one Mogul type locomotive and one Mikado type locomotive from the American Locomotive Company, Montreal Works.

The Tampanga Sugar Development Company, Philippine Islands, ordered 2 Mogul type locomotives from the Baldwin Locomotive Works.

The Great Northern Railway has ordered 2 electric locomotives, to be built jointly by the Baldwin Locomotive Works and the Westinghouse Electric & Manufacturing Company.

The Texas & Pacific Railway has ordered 5 Mountain type locomotives from the Baldwin Locomotive Works and fifteen 2-10-4 from the Lima Locomotive Works.

The Canadian Pacific Railway has ordered 4 snow plows for use on double track, and 7 snow plows for single track service, from its Angus shops.

Passenger Cars

The Illinois Central Railroad has ordered 10 motor cars and 10 trailers for suburban service from the Pullman Car & Manufacturing Company. These cars will be equipped with roller bearings.

The American Potash and Chemical Corp. is inquiring for one passenger and baggage car.

The Chicago, Rock Island & Pacific Railway is inquiring for five horse express cars.

The Canadian National Railways has ordered 60 passenger train cars, distributed as follows: Five cafe parlor cars, 2 buffet club cars and 30 colonists' cars from the Canadian Car & Foundry Co., and 12 baggage and 30 colonist cars from National Steel Car Corporation.

The North American Car Company is inquiring for 50 express refrigerator cars.

The Erie Railroad is inquiring for 25 passenger coaches, 3 combination baggage and mail cars, 5 express cars and 2 dining cars.

The Canadian Pacific Railway has ordered 5 sleeping car frames from the Canadian Car & Foundry Company and 5 from the National Steel Car Corporation.

The Baltimore & Ohio Railroad is inquiring for 10 combination baggage and mail cars.

The Detroit, Toledo & Ironton Railroad is inquiring for 2 combination baggage and mail cars and 2 passenger coaches.

The Union Pacific System has ordered from J. G. Brill Company two 73-ft. gas-electric rail motor cars.

The Chicago, South Shore & South Bend Railway is inquiring for 10 motor cars with an option on 5 additional cars and 5 trailers.

The Pullman Company has ordered 100 sleeping cars from the Pullman Car & Manufacturing Corporation.

The Chicago & North Western Railway has placed an order with the Electro-Motive Company for 5 Model 120, 275 hp. power plants for rail motor cars, the car bodies to be built by the Pullman Car & Manufacturing Corporation.

The New York, New Haven & Hartford Railroad is inquiring for 50 to 100 steel underframes for passenger cars.

The Southern Pacific System is inquiring for six dining cars.

The Chicago, Rock Island & Pacific Railway has ordered from the Electro-Motive Company six power plants, Model 148-400 hp., to be installed in existing cars, two power plants to a car.

The Union Pacific System has placed an order with the Electro-Motive Company for 4 Model 120 275 hp. power plants for rail motor cars, the car bodies to be built by the Pullman Car & Manufacturing Corporation.

The Delaware, Lackawanna & Western Railroad has ordered 1 combination baggage and mail car from the American Car & Foundry Company.

The New York Central Lines has placed orders for 119 passenger train cars.

The Richmond, Fredericksburg & Potomac Railroad has ordered one cafe car from the Pullman Car & Manufacturing Corporation.

The Pacific Electric Railway is inquiring for 10 center entrance street cars.

The Southern Pacific System is inquiring for 25 coaches, 5 three-compartment coaches, 10 baggage cars and 6 combination baggage and mail cars.

The Chicago, Rock Island & Pacific Railway has ordered 3 72-ft. gas-electric motor cars, equipped with the Mack-International Motor Truck Corporation's dual unit power plants, with the bodies to be built by Cummings Car & Coach Company.

Freight Cars

The Chicago, Milwaukee, St. Paul & Pacific Railway is inquiring for 2 flat cars of 100 tons' capacity.

Pennsylvania Railroad is considering reviving its inquiry for 300 passenger train refrigerator cars.

The Southern Pacific System is inquiring for 50 caboose cars.

Chicago, South Shore & South Bend Railway will buy 15 motor cars and five trailers.

The Canadian Pacific Railway has ordered 40 caboose cars from its Angus Shops.

The Chicago, Rock Island & Pacific Railway has ordered 500 steel underframes from the Pennsylvania Car Company.

The Virginian Railway is inquiring for 1,000 hopper car bodies of 57½ tons' capacity.

Chicago and Northwestern Railway has ordered five motor car bodies from the Pullman Car & Mfg. Corporation.

The United Sugar Company of Mexico is inquiring through the car builders for 10 cane cars of 40 tons' capacity.

Chicago Rapid Transit Company is now inquiring for 50 to 100 motor cars and 50 to 100 trailers.

The Barrett Company is inquiring for 100 insulated tank cars of 10,000 gal. capacity.

The Pacific Fruit Express has ordered 600 steel underframes for refrigerator cars from the American Car and Foundry Co., to be used for building cars in its own shops.

The Chicago & Northwestern Railway has ordered 300 general service cars from the Siems-Stemble Company.

The St. Louis-San Francisco System is inquiring for underframes and superstructures for automobile cars.

The Canadian National Railways has ordered 60 ballast cars from Canadian Car & Foundry Company and 200 ballast cars from Eastern Car Company.

The Pennsylvania Salt Manufacturing Company, Philadelphia, Pa., has ordered from the General American Tank Car Corporation, 2 tank cars to be used for the shipping of liquid chlorine.

The Chicago, Rock Island & Pacific Railway is in the market for five horse express cars.

The Union Pacific System has ordered four motor car bodies from Pullman Car & Mfg. Corp.

The Chicago, Burlington & Quincy Railroad is rebuilding 250 ballast cars in its own shops at Galesburg, Ill.

The Pere Marquette is inquiring for 20 steel air-dump cars.

The Atlantic Coast Line has ordered 200 phosphate cars from the Tennessee Coal, Iron & Railroad Co.

The Pond Creek Collier Co. has ordered 60 mine cars from the Hockersmith Wheel & Mine Car Co.

Ringling Brothers have ordered 65 all-steel circus cars of special construction from the Warren Tank Car Company.

The Southern Cotton Oil Company, Savannah, Ga., is inquiring for 20 tank cars of 8,000 gal. capacity.

The St. Louis-San Francisco Railway will purchase 250 car bodies.

The Southern Pacific System has ordered 250 automobile cars from the Tennessee Coal, Iron & Railroad Company.

The Standard Oil Company of New Jersey has ordered 6 50-ton steel box cars from Pressed Steel Car Company.

The Kansas City, Mexico & Orient Railroad is reported to be inquiring for 100 box cars.

The Northern Pacific has ordered 50 caboose car underframes from the Pacific Car & Foundry Co.

The Southern Pacific System has ordered 175 tank cars from the American Car & Foundry Company.

The Western Maryland Railway has placed orders for miscellaneous shapes and plates, fabricated, for reconditioning some of its hopper cars.

The Amtorg Trading Corporation has ordered 16 flat cars of 30 tons' capacity from the Magor Car Corporation.

The North American Car Corporation has ordered 300 refrigerator cars from Pressed Steel Car Company. The corporation is also inquiring for 500 tank cars in addition to 300 poultry cars.

The Pacific Fruit Express has ordered 400 steel underframes for refrigerator cars, from the Pacific Car & Foundry Company.

The Southern Pacific System will purchase 500 flat cars and 50 gondola cars, in addition to the like numbers on which prices were recently asked.

The Chicago & Northwestern Railways is inquiring for 200 flat cars of 50 tons' capacity.

The Norfolk and Western Railway will rebuild 250 all-steel gondola cars at its Roanoke, Va., shops.

The Erie Railroad is inquiring for 500 box cars of 40 tons' capacity, 500 automobile furniture cars 40 ft. 6 in. long, 100 automobile furniture cars 50 ft. long of 50 tons' capacity and 5 depressed flat cars of 100 tons' capacity. Repairs will also be made to 2,485 box cars.

The North Western Refrigerator Line Company has ordered 500 steel underframe refrigerator cars 40 ft. long of 40 tons' capacity, and 100 refrigerator car underframes from the American Car & Foundry Company.

The Egyptian State Railways are inquiring through the car builders for 320 low side gondola cars of about 10 tons' capacity.

The Cudahy Packing Company has ordered 100 underframes for refrigerator cars, from the Pullman Car & Manufacturing Corporation.

The Chicago, Milwaukee, St. Paul & Pacific Railway has ordered 1,250 box cars from the Bettendorf Company, 500 box cars from the General American Car Company, 500 box cars from the Pressed Steel Car Company, 250 box cars from the Pacific Car and Foundry Company, 300 automobile cars from the American Car and Foundry Company, 500 hopper cars from the Pullman Car & Mfg. Corp'n., and 500 hopper cars from the Standard Steel Car Company, 500 stock cars from Ryan Car Company, and 150 stock cars from the Siems-Stemble Company.

The Fruit Growers Express has ordered 600 steel underframes from the American Car & Foundry Company. These underframes will be used in refrigerator cars to be built in the Fruit Growers Express Company Shops.

Supply Trade Notes

Nelson G. Craig has been appointed district manager at Philadelphia, Pa., with office at 1420 Walnut street of the **Oliver Iron & Steel Corporation**, Pittsburgh.

H. D. Savage, for many years vice-president, has been elected president of the **Combustion Engineering Corporation**, New York.

The Roller Bearing Company of America, Newark, N. J., has purchased the plant of the **Mercer Motor Car Company**, Trenton, N. J. The Roller Bearing Company will install its present equipment in that plant and add new equipment required to take care of its increasing sales.

Kenneth Grant has been appointed representative of the **Foote Brothers Gear & Machine Company**, with headquarters in Chicago, Ill.

Harry Woodhead has been appointed general manager of the hydraulic pressed division of the **Truscon Steel Company**, Youngstown, Ohio, with headquarters in Celveland.

Marcus Chase, sales manager of the **Niles-Bement-Pond Company** of Massachusetts with headquarters at Boston, Mass., has resigned. He is succeeded by **M. S. Bradley**, who has been an assistant to Mr. Chase.

O. B. Capps, formerly eastern sales manager of the Locomotive Stoker Company, has formed a company known as **O. B. Capps, Inc.**, with O. B. Caps as president, and office at 420 Lexington avenue, New York. The new corporation expects to specialize in locomotive and car equipment sales.

The Safety Car Heating & Lighting Company has removed its Canadian offices from 511 St. Catherine street, West, to 10 Cathcart street, Montreal.

Edgar S. Ross, senior fellow of the Mellon Institute of Industrial Research, Pittsburgh, Pa., has resigned to become manager of research and development of the **Headley Good Roads Company**, Philadelphia.

The Southern Wheel Company has removed its Pittsburgh office from 1102 Commonwealth building, Pittsburgh, Pa., to West Homestead, Pa.

Thomas S. Stephens of **Manning, Maxwell & Moore, Inc.**, New York manager of railroad machinery sales, has resigned.

R. F. DeMott has been appointed district manager of the **Franklin Railway Supply Company, Inc.**, with headquarters at St. Paul, Minn.

A. L. Van Horn, assistant superintendent, United States Railway Mail Service in charge of postal car construction has resigned to become a representative of the **Wood Conversion Company, with headquarters at Washington, D. C.**

H. Van Zandt, sales representative of the **Illinois Steel Company**, has been appointed assistant general manager of sales in charge of the structural steel division.

C. Irving Dwinell, formerly sales engineer for the **General Electric Company** at Providence, R. I., has been appointed manager of the Boston, Mass., branch of the **United States Electrical Tool Company.**

L. Weisenburger, sales representative at Chicago of the **Hale-Kilburn Company**, has resigned, effective April 30th.

W. H. Post, representative of the **Timken Roller Bearing Service and Sales Company** with headquarters at Cleveland, Ohio, has been promoted to manager of the Pittsburgh Pa., office.

The Wright Manufacturing Company, Lisbon, Ohio, manufacturers of chain hoists, trolleys and cranes, has sold its business and trade name to the **American Chain Company, Inc.**, Bridgeport, Conn.

The Transportation Equipment Corporation of New York, has been appointed sales representative for the railroads, **A. Allan & Son,** Harrison, N. J., manufacturers of the Allan Red Metal King type packing ring for superheat service.

William H. Moore, formerly representative of the **Metal & Thermit Corporation**, has been appointed sales manager of the **W & B Company** and the **Burnside Steel Foundry Company**, Chicago.

F. A. Ernst, formerly representative of the **American Rolling Mill Company**, with headquarters at Chicago, has been appointed assistant district sales manager of the **Inland Steel Company** with headquarters at St. Louis, Mo.

Ward A. Miller, New York sales manager of the **Midvale Company** of Philadelphia, has been appointed a vice-president of the **Vanadium Corporation of America**, New York, and will have general supervision over all commercial affairs of the corporation.

The Ingersoll-Rand, Inc., has succeeded the **Ingersoll-Rand Drill Company** with offices at 314 North Broadway, St. Louis, Mo. A branch operating under the St. Louis office has been opened at 226 West A street, Picher, Okla.

Hugh K. Christie has been appointed a special salesman in the railroad department of the **Whiting Corporation**, Harvey, Ill.

The Graham Bolt & Nut Company, Pittsburgh, Pa., has opened a district office at 1 East Forty-second street, New York City, under the direction of **W. K. Graham.**

W. R. Voorhees & Co., San Francisco, Cal., and Seattle, Wash., are now representing in the western states the **Billings & Spencer Company**, Hartford, Conn.

Alfred E. Munch, Jr., has been appointed representative of the **Rollway Bearing Company, Inc.**, Syracuse, N. Y.

The Columbus McKinnon Chain Company, Tonawanda, N. Y., has acquired control of the hoist division of the **Chrisholm-Moore. Manufacturing Company**, Cleveland, Ohio. The general sales offices and factory will continue to operate in Cleveland, Ohio, under the same name as in the past.

Thomas J. Bray, president of the **Republic Iron & Steel Company**, Youngstown, Ohio, has resigned.

J. E. Linahen, vice-president in charge of sales and service of the **Galena Signal Oil Company**, with headquarters at Franklin, Pa., has resigned.

Webb G. Krauser, representing the **Union Draft Gear Company** and the **Universal Draft Gear Attachment Company**, has removed his office from 120 St. James street to 360 St. James street, Montreal, Que.

The Hammond Bolt and Nut Company, Chicago, has been organized to take over the manufacture of bolts and nuts formerly conducted by the **Illinois Car and Manufacturing Company. M. J. McConough**, vice-president of the Illinois Car and Manufacturing Company, has been elected president of the new company.

Harold L. Hughes and **William A. Forbes** have been appointed assistants to the president of the **United States Steel Corporation** of New York.

N. Petinot, general manager of the sales at New York of the **Vanadium Corporation of America**, has been appointed assistant to the president.

Harlan W. Bird has been appointed district representative of the **Bayer Company**, St. Louis, Mo., with headquarters in the Conway building, Chicago.

R. J. O'Brien has been appointed assistant to transportation sales manager with the **Westinghouse Electric & Manufacturing Company** with the Atlantic seaboard district as his territory. Mr. O'Brien graduated from the University of Minnesota as an electrical engineer in 1911. After graduation, he was made resident engineer of the Great Northern Railway at New Rockford, N. D. Following this, for approximately a year and a half Mr. O'Brien was apprentice at the Westinghouse plant at East Pittsburgh.

From 1913 to 1917 Mr. O'Brien was engaged in general engineering work for Gibbs & Hill, consulting engineers. From 1917 to 1920 he was an officer of the A. E. F. in the United States and France. In April, 1920, Mr. O'Brien was appointed to the staff of F. H. Shepard, director of heavy traction of the Westinghouse Company and has been the Westinghouse representative on the Virginian electrification. He has remained on Mr. Shepard's staff, recently actively engaged in self-propelled car work, until his new appointment as assistant to transportation sales manager.

J. I. McCants has been appointed southern sales manager of the **Bates Valve Bag Corporation**, Chicago, with headquarters at Birmingham, Ala.

H. W. Dillion, formerly sales engineer of the **Chicago Pneumatic Tool Company** and **J. P. Rapp**, formerly with **Standard Steel Car Company** and who had served as inspector of the American International Shipbuilding Corporation, is now with the **Gold Car Heating & Lighting Company** in its eastern sales department, Brooklyn, N. Y.

The appointment of **C. W. Stone**, manager of the **General Electric Central Station Department**, to the position of consulting engineer, and the selection of **M. O. Troy** as manager of the Central Station Department, have been announced by President **Gerard Swope** of that company.

The Hydraulic Pressed Steel Company, Cleveland, Ohio, has been purchased by the **Truscon Steel Company**, Youngstown, Ohio, and will be operated as their Pressed Steel Division. The entire plant is being completely modernized to insure the most efficient production. With this increase in facilities, the Truscon Steel Company will have one of the largest capacities for furnishing pressed and deep drawn steel of every description. The improvements are proceeding rapidly, and full productive capacity will be available shortly. Inquiries may be addressed either to the Truscon Steel Company at Youngstown, Ohio, or to the Hydraulic Pressed Steel Company, Cleveland, Ohio.

J. C. Goodnight has joined the selling force of the Detroit office of the **Black & Decker Company** of Towson, Maryland. **Leon A. Hardy** replaces Jack Caffrey in the New York Black & Decker branch as salesman.

Items of Personal Interest

E. B. De Vilbiss, superintendent of motive power of the Pennsylvania Railroad at Williamsport, Pa., has been appointed superintendent of motive power of the New Jersey division, and **Eliot Sumner** is made assistant to the general superintendent of motive power, eastern region.

C. L. Adams has been appointed general foreman machine shop of the Southern Railway at Birmingham, Ala., succeeding **O. C. Martin**, deceased.

W. T. Capps has been made stoker supervisor of the Baltimore & Ohio Railroad with office at Baltimore, Md.

J. Sims has been appointed road foreman of engines, jurisdiction between Birmingham, Ala., and Meridian, Miss., of the Southern Railway, succeeding **J. W. Turnipseed**, transferred.

J. E. Hardy was appointed road foreman of engines, jurisdiction between Birmingham, Ala., and Chattanooga, Tenn., succeeding E. J. Frazer, transferred.

Thomas J. Cutler, who has retired as mechanical superintendent of the Eastern lines of the Northern Pacific Railway with headquarters at St. Paul, Minn., had completed nearly 30 years of service in the mechanical department of that railroad.

Henry Kelso has been appointed road foreman of engines, jurisdiction Birmingham, Ala., to Columbus, Ga., of the Southern Railway and Northern Alabama Railway.

F. T. Huston has been appointed master mechanic of the Pennsylvania at Dennison, O.

L. B. Jones, master mechanic of the Pennsylvania Railroad at Harrisburg, Pa., has been transferred to Columbus, Ohio. He is succeeded by **J. T. Leech**, formerly master mechanic at East Altoona. **H. B. Chaflin**, formerly master mechanic at Dennison, Ohio, succeeds Mr. Leech at East Altoona, Pa.

D. C. Elliott has been appointed master mechanic of the Canadian National Railways at Hornepayne, Ont. He succeeds **J. Hawkins**, transferred.

F. Clinkscales has been appointed traveling engineer of the Southern Pacific Company at Austin, Texas, succeeding **C. R. Haberlin**, transferred.

G. R. Curry, special apprentice has been promoted to inspector of motive power in the Altoona machine shops of the Pennsylvania Railroad.

Frank J. Yochem, foreman boilermaker of the Missouri Pacific System at Kansas City, has been appointed to a similar position at Sedalia, Mo.

B. M. Swope, formerly master mechanic, Columbus, Ohio, shops of the Pennsylvania Railroad, has been appointed Superintendent of motive power of the Central division with headquarters at Williamsport, Pa.

New Publications

Books, Bulletins, Catalogues, Etc.

Mundet Jointite Cork Tile is the name of a new bulletin just published by L. Mundet & Son, Inc., 461 Eighth Ave., New York City, who are specialists in the manufacture of cork products.

The bulletin emphasizes the fact that Mundet Jointite Cork Tile is profitably used in the smallest homes as well as in the largest institutions. An attractive photograph is shown on the front page of the entrance to the Kirby Telephone Exchange, Cincinnati, Ohio., Indicating that cord tiling when properly laid is ornamental as practical. Cuts in the bulletin plainly show the difference in color which is effected solely by varying the temperature of baking. No artificial coloring is used whatever. The bulletin includes in detail such subjects as Size of Installations, Slipperiness, Warmth, Specifications, etc. Fourteen pertinent facts are listed as reasons why Mundet Jointite Cork Tile should be used in corridors, halls vestibules, ramps, stairstreads, ships, hospitals, and numerous other places. It has a very wide and useful range of application. Ask for "A. I. A. File Number 23b-Cork Tile Floors," and a copy will be mailed to you, free.

Coaling Stations—The Ogle Construction Company, Chicago, has issued a bulletin on small capacity, low cost coaling stations designed for use at terminals where only 50 to 100 tons of coal are handled in 24 hours or at main line points where from 5 to 10 locomotives are coaled daily. This bulletin sets forth the advantages and the plans and specifications under which the stations are constructed and contains pictures of a few plants now in operation.

100 and 1 Ways to Save Money with Portable Compressors—Ingersoll-Rand Company, of 11 Broadway, New York, has just completed the sixth edition of its popular 140-page, two-color book of the foregoing title. In this book the Company has embodied comparative cost data on its portable air compressors and air-operated tools (rock drills, paving brookers, clay diggers, backfill tampers, grinders, hoists, riveting hammers, chippers, metal drills, etc.). The information has been put together in handy-reference, cross-index form. In most cases, figures are present on a man-hour basis so that they can be readily applied to local conditions in any part of the world.

Free copies may be obtained by writing to Ingersoll-Rand Company, 11 Broadway, New York City, or any of its local Branches in any part of the world.

On many classes of work, one man using a portable compressor and some one of the above-mentioned tools can do as much as ten men formerly did by hand. "100 and 1 Ways" contains accurate tables showing the number of tools that any given portable will operate.

It is interesting to note the long life of this kind of construction machinery. For instance many of the portable compressor units that were put in service by the company twelve years ago are still in operation today.

The compressor itself, the heart of the unit, is the result of nearly sixty-years' experience gained in pioneering and developing such machines. Waukesha heavy-tractor-type motors (with the patented Ricardo Head) are used exclusively on all six sizes.

Ingersoll-Rand Company's world-wide service organization is supplemented by local stock of complete machines and spare parts. The user of this equipment may thus feel assured of continuous satisfactory operation, regardless of the location of his work.

Belt Dressing Facts—This is the name of a new 12 page booklet just published by E. F. Houghton & Co., Philadelphia, Pa. Every belt user should have a copy. It is very well written and it contains much valuable information on the proper care of belts. The Sub-headings are as follows: Belt Lubricant Essential; Liquid Lubricant is Best; Avoid Sticky Dressings; Slack Belts Undesirable; Loose Belts Waste Power; What a Dressing Should Do; Specially Adapted for the purpose; Houghton Experience; Packages; Directions.

Gas-Electric Rail Cars—A four page pamphlet has been issued by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., under the title "A Tool of Modern Railroad Efficiency" which outlines the position of the gas-electric rail car and deals specifically with the Westinghouse torque governor control. The principal feature of this control is to obtain the fullest possible use of the engine through automatic external regulations of the main generator.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

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Gas-Electric Cars of the New York Central Lines

By N. L. Freeman, Railway Equipment Engineering, Westinghouse Elec. & Manufacturing Company

The gas-electric car is one of the most modern devices of transportation. Its application is one of economy in all respects and likewise reliability in handling the service on lines where the service does not warrant the capacity of full sized passenger trains. The cars are essentially built for passenger and baggage service and are equipped with gasoline engines which drive through electric transmission. This is recognized as the only satisfactory type for these equipments.

The electrical transmission consists of a generator for each engine and one or more motors mounted in the trucks and connected to the generators. The simplest local system is commonly referred to as drum control of K-control. Remote control may be any one of several systems, the most important being the electro-pneumatic system. A K-controller is a drum controller which handles the main circuits through heavy copper fingers bearing against the brass segments with which the two drums are equipped. Electro-pneumatic control requires the operator to manipulate only low-voltage, low-powered control currents which operate magnet valves located on pneumatic switches at some distance from the operator. These switches are closed by air pressure and opened by springs.

New Gas-Electric Car of the New York Central Lines

and most desirable type of motor for traction purposes is, without question, the series motor. Motors of this type are universally used on gas-electric cars as they are on most electric locomotives and cars. The generators used in connection with these motors are of special design in order to adapt the engine output most satisfactorily to the characteristics of the traction motors. Due to the fact that gasoline engines run normally in one direction, are run idle when not developing traction, and are stopped when the car is off duty, the motors and generators are connected, not permanently, but through a control system. This control system serves to break the circuits and change them at the desired time for the necessary car operations. Frequently this system involves further refinements for improved operation and reliability.

There are two systems of controlling the main electrical circuits of a gas-electric car, local and remote. The

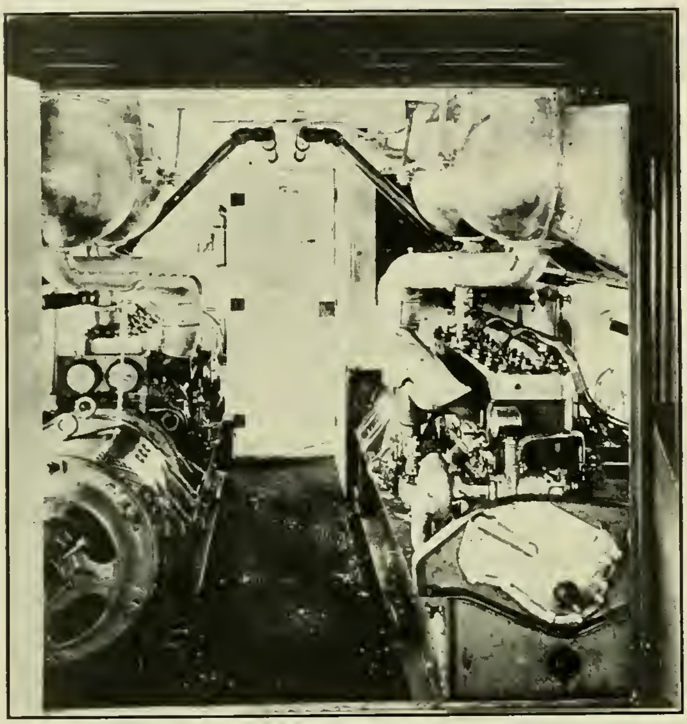
Electro-pneumatic control for gas-electric cars is the standard type supplied by the Westinghouse Electric and Manufacturing Company. It affords the following definite advantages:

1. Safety for the engineman by removing high voltage circuits from his proximity.
2. Accessibility and proper distribution into easily maintained units.
3. Additional safety to everyone, as the car must have air before it is operative.
4. Pneumatic switches are more reliable at all times than any other type and require a minimum amount of power to operate.

The New York Central now has a number of gas-electric cars, fourteen of them are equipped with electro-pneumatic control and electrical equipment supplied by the Westinghouse Electric and Manufacturing Company.

Of these fourteen, eight were built by the J. G. Brill Co., two by Standard Steel, and one by the International Motor Co. There are a number of differences in these equipments, but they have in common electro-pneumatic control and engine starting using the main generators as starting motors operated from 32 volt batteries.

The 250 hp. Brill-Westinghouse engines in the Brill cars drive type 176-A generators and YG-6-A exciters. The traction motors on the single engine cars are Westinghouse type 557-D-8. On the double power plant car



Power Plant of New York Central's Gas-Electric Car

Westinghouse motors type 569-C-4 are used. These are heavier duty motors than the type 557-D-8. Each generator drives two of these motors which are arranged for both series and parallel operation. In order to fit the engine output to the traction motor characteristics or vice versa, the generator receives its field current from the exciter which has a battery field and a differential field which carries main generator current. This prevents the generator from overloading the engine. One generator is used per engine.

On the single power plant Brill Cars the radiators are cooled by a fan driven by a motor connected to the main generator. This is a horizontal type motor. On the double power plant Brill car vertical type motors are used for the same purpose. The air compressors on these cars are of standard type and their driving motors connect directly to the main generator the same as the blower motor.

All the Brill cars have a hand throttle and are double end. The reversing switch is of the plug type, while a toggle type snap switch serves as a series parallel selector. The high voltage control equipment, as well as field and starting switches, is located in a cabinet to the rear of the engine room. Near this cabinet are located two carbon pile regulators. One of these is for regulating the battery charge from the exciter and the other for regulating the lamp voltage. The car control current also is taken from this regulator. It is at the standard 32 volts as used on all cars.

The double power plant Mack car built by the International Motor Company also uses Westinghouse type 180-A generators direct-connected to Mack 120 hp. engines. These generators do not have exciters but are shunt wound. Instead of a differential field they are equipped with an adjustable field resistor to be adjusted by the operator who has an indicating light connected to the engine governor. This field variation is controlled by the main throttle handle of the controller and in addition may also be controlled by the reverse lever. This car does not have series parallel operation for there is no interconnection between the two motors or generators. Instead, traction motor field shunting is provided which may be used as desired by the enginemen. Battery charging is obtained from the main generator during idling and from a small charging generator during running. No regulators are required.

On this Mack car there are no blower motors. Instead, the exhaust is used to pull air through part of the radiators while the remainder of cooling is obtained by roof radiators. The system includes thermostatic control.

The compressors are mechanically driven from the engines and are mounted as part of the power plant assembly.

There is no direct mechanical connection from the operator's compartment to the engine to regulate the throttle. Instead, the throttle is controlled remotely by air cylinders and magnet valves.

The Standard Steel Car Company cars have the largest power units. Westinghouse type 181 generators are used, one on each car with a 300 hp. Sterling Viking engine. The traction motors are Westinghouse type 569-C-4 as on the Brill double power plant car. The 181 generator is equipped with a YG-11 auxiliary generator for charging purposes as well as operating the compressor and carrying the generator field. This generator does not have a main differential field similar to the type 176-A generator. Instead, its field is regulated by a torque governor which is an electrical device for keeping constant load on the engine.

The operator has a Westinghouse type 567-D centralized control station for handling the control circuits and auxiliary electrical equipment. The control of lights, sanders, throttle, series parallel, reversing, and engine starting are centralized into this unit. This equipment also uses an electro-pneumatic throttle as on the Mack car.

These cars do not have blower motors but depend entirely on roof radiators without fans. The compressors operate at 32 volts from the charging source which is the auxiliary generator during running or the main generator during idling. No charging regulators are required on this equipment but a carbon pile regulator maintains constant voltage on the lighting circuits.

All of the above equipments have power plants mounted longitudinally, and in the case of double power plant cars there is an aisle between the two power units. The engineer's safety has been carefully considered from all viewpoints, both electrical and mechanical, in each equipment.

Westinghouse Brakes for Belgian Railways

The Belgian State Railways are reported to have placed an order with the Westinghouse Brake & Saxby Signal Company for air brake equipment for their lines. The Westinghouse type of brake equipment has been specified by the Belgian Railways for use on their lines, in keeping with the provisions set forth in the Versailles Treaty to the effect that all governments should equip the rolling equipment of their respective railways with air brake appliances that will work uniformly during the interchange of rolling stock.

As previously reported the French government has already adopted the Westinghouse air brake.

Power Brakes and Modern Train Operation

A Paper Presented to the A. S. M. E.

By L. K. Sillcox, Asst. to Pres., New York Air Brake Company

In 1833 Stephenson patented his steam brake in which steam pressure acting on a movable piston was made to take the place of the hand-operated mechanism by which the force was applied through a system of rods multiplying levers (and cams in this case) to the brake shoes. It will, therefore, be observed that there was a source of power for the brakes in conjunction with means whereby this power was made to act upon the brake rigging proper —a "brake" cylinder with movable piston—a foundation "brake" gear and a means for transmitting the force exerted, namely the "brake" shoes.

Hand-operated car brakes, with various forms of foundation brake gear, met all the requirements for a considerable period, though a general realization of the necessity for some form of continuous power brakes were gradually becoming a necessity.

In 1853 the Creamer brake was brought into use, consisting of a large spiral spring attached to the brake staff, the same being wound up immediately after leaving a station. Attached to mechanism was a cord which ran through the train to the locomotive cab, and the brake was so designed that when the engineman pulled the cord the coil springs on each car were released, and these at once wound up the chains leading to the foundation brake gear, in consequence of which the brake shoes were brought against the wheels.

Two years later (1855) the Loughridge chain brake came into use and was formed from a system of rods and chains continuously connected throughout the train. Each car was fitted with two pairs of small pulleys, each pair sliding toward the other upon an iron framework, but held in release position by a spring. A top connection rod fastened to each pair of pulleys and formed communication with the foundation brake gear. The locomotive was fitted with a drum in conjunction with a worm and gear to a small friction wheel, the latter being actuated by a lever conveniently located in the cab for use while running. This hand lever was used to bring the friction wheel in contact with the bearing face of one of the driving wheel tires, thereby causing the drum to wind up the chain and shorten its length throughout the train, thus applying the brakes on each car connected throughout.

The first pneumatic brake was a vacuum type patented by James and Charles Nasmyth in 1844, while in 1848 Samuel C. Lister patented an air brake having an axle driven pump, reservoir and cylinder, with pipe and connections on the various cars, thus constituting a straight-air brake equipment, much the same as that which was brought out in 1869 to be operated by the train crew in the caboose and not by the engineman.

Later attempts made in trying to develop the problem resulted in devising a brake connected by levers to the draft rigging, but this scheme not being workable, was soon abandoned. Following this an inventor named Ambler developed a chain brake which was operated by the revolving of a windlass in the engine, the chain thus being taken up and the brake levers on each car made to operate. Mr. Westinghouse discovered the idea of exchanging the windlass for a cylinder beneath the locomotive, the piston of which was formed to connect with the chain so that the drawing in of the piston by the application of steam from the locomotive would give a more accurate control of the brakes than was possible with the windlass device. Because of the excessive piston travel necessary on trains having more than four or five cars, the system was changed to one furnishing a cylinder beneath each car with a flexible pipe connecting each one to the locomotive for its supply of steam. It was now not found possible to properly transmit the steam, even in favorable weather, and, consequently, the plan was given up.

Mr. Westinghouse next turned his attention to the work being done with compressed air in driving tunnels where connected piping as long as 3,000 ft. was employed. He immediately discovered that this would suffice for any length of train and thereupon, began actively to develop designs of apparatus suitable for the purpose, filing his first patent application in 1867 and having his first patent allowed on April 13, 1869. Work on the sample equipment for demonstration purposes, consisting of an air pump, a main locomotive reservoir and four car cylinders, was started at the same time in a machine shop in Pittsburgh and this apparatus was finally completed in the summer of 1868, or almost 40 years after the development of the first locomotive. Prior to that hand brakes had to be resorted to. So that a service test might be carried out, the Pennsylvania Railroad gave Mr. Westinghouse permission to fit up the Steubenville accommodation train, which consisted of a locomotive and four cars. The Westinghouse Air Brake Company was organized in July, 1869, and the Pennsylvania Railroad was the first to adopt (1869) the system of continuous brakes, and in its developed form, it has become, not only a standard necessity for present day operation in the United States, Canada and Mexico, but throughout the world. In 1879 there were 3,000 locomotives and nearly 10,000 cars fitted with Westinghouse brakes. It is well to state that from 1869 to 1872 straight air brakes were employed. In 1872 the automatic air brake followed. Fifteen years later the quick action brake was produced, and in 1894 the high speed brake was brought out, this being the commencement of passenger brake divergence from freight brake equipment when higher brake pipe pressures were introduced in passenger service in order to control heavier cars in trains running at higher speeds. A high speed automatic reducing valve, was used, which provided a wider margin between service and emergency braking. With the provision of still heavier passenger cars and longer trains operating at greater speeds it soon developed that another step, more effective than had been taken in connection with the high speed brake, was needed and the result was the introduction of the L. N. type passenger brake, in about 1905. This equipment contained quick service, graduated release, high pressure in emergency and uniform recharge. When in 1909 all steel passenger cars began to come into service and form the major part of train consists, it was concluded that, in order to provide similar standards of relative effectiveness, as were common to the older forms of equipment on lighter cars, extensive and complete tests should be run in order to arrive at suitable factors to definitely determine what the projected requirements should call for. This matter was taken in hand by the committee on Train Brakes and Signal Equipment of the Master Car Builders' Association while meeting in Pittsburgh during July, 1909. It was similar to the first action taken by this association in 1885 when they appointed a committee to report upon the feasibility of the application of power brakes to freight trains, and that body, having the problem to solve, inaugurated what are now known as the Burlington (Iowa) brake trials made during 1886 and 1887. Two trains, of 50 cars each, one fitted with a vacuum brake and the other operated with compressed air brakes, the latter being devised by Mr. Westinghouse and later known as the quick action automatic air brake. The immediate result of these tests proved the importance of prompt serial action and more uniform application of the brakes on the rear cars of the train, if the effect of very serious and destructive shocks was to be avoided.

The High Speed Brake

The Westinghouse-Galton experiments carried on in England in 1878, first demonstrated (and every investigation made since then has confirmed the fact) that, while the adhesion between the wheel and the rail—which causes the wheels to continue rotating was practically uniform at different speeds, the friction between the brake shoe and the wheel—which resists the rotation of the wheel, and thereby stops the train—was considerably less when the wheels were revolving rapidly than when they rotated slowly. It was thereby demonstrated that a greater pressure could not only be safely applied to the wheels by the brake shoes, at high speeds, but also that such considerably higher brake shoe pressures must of necessity be applied to the wheels at high speeds, in order to resist the motion of the train as effectively as with the more moderate brake shoe pressures at low speeds. During the progress of the experiments in England, special apparatus, of a somewhat delicate character, was employed with the existing type of standard automatic brake to regulate a variable pressure of the brake shoes upon the wheels—beginning with a high pressure at high speeds and reducing to a moderate pressure when the speed became low—whereby much shorter train stops were secured than had ever been previously attained in any other way. No practical application of this method of operation was made in regular service, the reasons being (1) that the conditions of regular train service were not such, at that time, as to necessitate the utilization of this principle and its added complication, (2) the apparatus being of a somewhat delicate and complicated nature, making it inconsistent with the exacting element of complete reliability which, of necessity, is a basic requirement for any power brake apparatus.

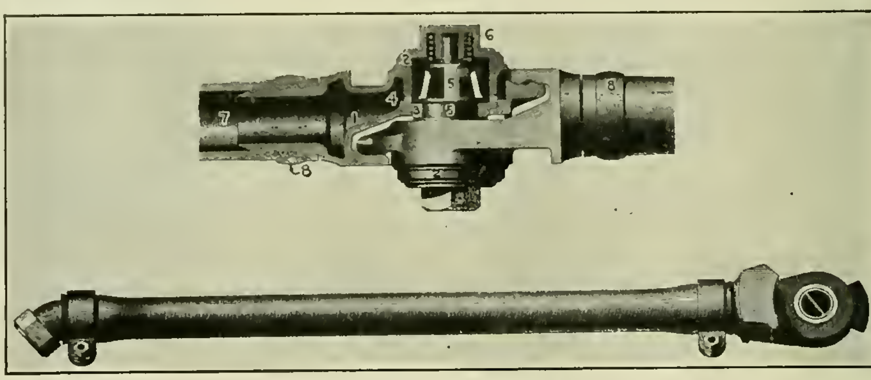
With the development of the quick action brake in 1887 following that of the straight air brake of 1869 and the plain automatic air brake of 1872, the presence of the emergency brake, in addition to the ordinary automatic brake for service use, prepared the way to an entirely practical application of the principle previously discovered in England, by means of simple and reliable devices. Just previous to this time, the Master Car Builders' Association took intelligent and appropriate steps compelling the railroads to improve the foundation brake gear on equipment with the result that the stronger structures provided were found to be sufficiently adequate, at the time, for such increased duty as was imposed upon it in producing the increased brake shoe pressures which were utilized at high speeds by the High Speed Brake brought out in October, 1894.

The apparatus of this brake was simple and consisted of the old standard quick action air brake mechanism, as ordinarily applied to passenger cars and locomotives, to which was only added an automatic reducing valve. This automatic pressure reducing valve was so constructed that it remained inoperative in all service applications of the brake, unless, at any time, the brake cylinder pressure became greater than 60 lbs. per square inch (for which the automatic pressure reducing valve was normally adjusted), in which case the reducing valve operated to promptly discharge from the brake cylinder as much air as was necessary to restrict the brake-cylinder pressure to 60 lbs. It was thus possible to maintain, as a maximum, a brake cylinder pressure of 60 lbs., in all service applications of the brakes, regardless of the air pressure regularly carried in the brake-pipe and auxiliary reservoirs.

In an emergency application of the brakes the sudden admission of a large volume of air to the brake cylinder (only made possible by the quick action feature of locally venting the brake-pipe) raised the pressure more rapidly than it could be discharged through the service port of the automatic reducing valve, and the port thereby became partially closed, thus restricting the discharge of air from the brake-cylinder in such a manner that the pressure in the brake cylinder did not become reduced to 60 lbs. until a predetermined amount of time had elapsed.

Increase of Air Pressure

In order to cause the automatic reducing valve to become practically effective for producing the increased braking efficiency, for which it was known, the pressure of the air carried in the brake-pipe and auxiliary reservoirs was increased from 70 lbs. (the normal standard) to 110 lbs., per square inch. With this pressure in the brake-pipe and auxiliary reservoirs, an emergency application of the brakes, filled, almost instantly, the brake-cylinder with air at approximately 83 lbs. pressure, thereby increasing the braking power from about 90 per cent of the light weight of the car (the usual standard) to about 125 per cent and the applied pressure of the brake shoes upon the wheels increased $\frac{83-60}{60}$ or 38.8 per cent at that instant compared with that which was obtainable through merely using the quick action brake. The air pressure immediately began to escape from each brake cylinder, through the automatic reducing valve, and continued to do so until the brake cylinder pressure became 60 lbs., which was thereafter retained until the brakes were released by the engineman. Due to the high pressure normally carried in the auxiliary reservoirs (110 lbs.) a full service application of the brakes (charging the brake cylinders with air at 60 lbs.) might be made, and still leave the pressure in the auxiliary reser-



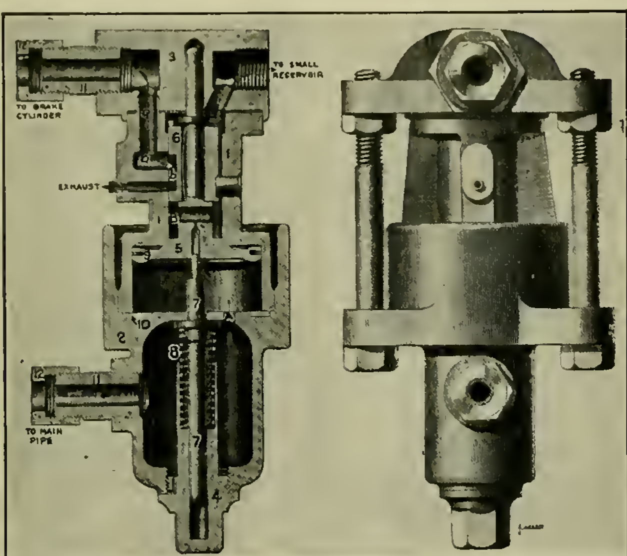
Hose and Coupling, 1869

1 Body
2 Cap Nut
3 Seat
4 Packing
5 Valve
6 Valve Spring
7 Hose
8 Hose Clamp

voirs at almost 86 pounds. If, after releasing the brakes, a second application of the brakes was demanded before there had been time to recharge the reservoirs, there remained an abundance of air, yet stored in the reservoirs to make an emergency stop shorter than that of the ordinary quick action brake when charged with 70 lbs. pressure. These advantages coupled with such a restricted brake cylinder pressure for all service applications of the brake, that wheel sliding was almost entirely avoided, required no further demonstration to insure recognition of their necessity upon important trains. By simple additions to the brake apparatus on the locomotive, the brake pipe pressure was easily and quickly changed to 70 lbs., when the locomotive needed to be used in other classes of service or vice versa.

Complications of High Speed Train Operation

In order to more fully appreciate the various advantages of improved brake apparatus upon trains running at high average rates of speed, it is necessary to keep in view the special circumstances under which such trains



Cross-Section and Elevation of Plain Automatic Triple Valve, 1872

1	Body	7	Graduating Stem
2	Cap	8	Graduating Spring
3	Bracket	9	Piston Ring
4	Graduating-Stem Nut	10	Gasket
5	Main Piston	11	Union Stud
6	Slide Valve	12	Union Nut

are operated. While ordinary local and secondary trains are frequently called upon to run at very high speeds where it is conveniently possible and for relatively short distances, this is accomplished under circumstances which involve no unusual risks. The chief characteristic of limited trains and also those operating in dense traffic territory is not so much the maximum speed attained as its high average rate between terminals, which necessitates a velocity through yards, at intersections, over switches and crossovers not demanded in any other service and, consequently, not provided for. Signals are generally located at distances, from the points to be protected, that will give ample space in which to bring trains to a stop from customary speeds, but they need to be sufficiently near to avoid interference with the orderly movement of trains and keep away from unnecessarily retarding their progress at remote distances. Because of this, the spacing of train signalling apparatus, on roads subject to dense traffic, has therefore been established upon these principles. The introduction of a train service in which the average speed is considerably greater than that for which the operating conditions of the railroad have been established, is accompanied by complications of greater moment than may be readily anticipated.

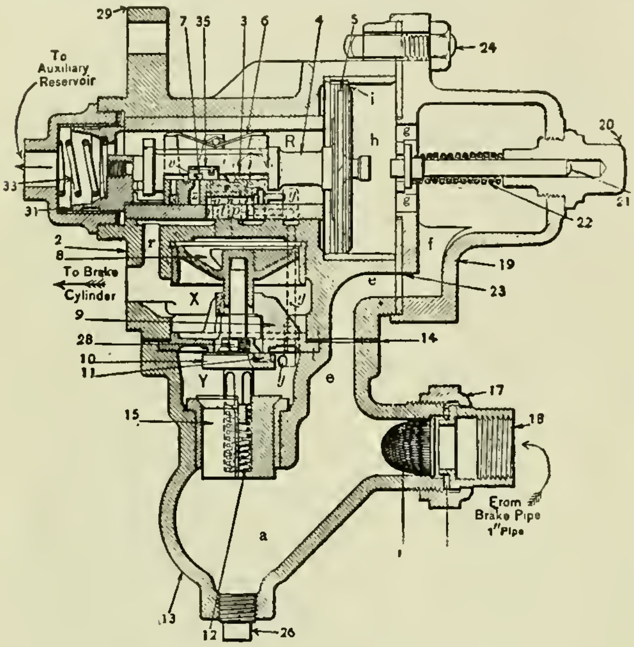
From a study of the fundamental physical laws governing the distance in which a train can be stopped from various speeds, we observe that at forty miles per hour the distance required is 1.8 times as great as that from which it can be stopped from a speed of thirty miles per hour. At fifty miles per hour, the stopping distance is 2.8 times as great as that necessary for thirty miles per hour, and 1.6 times as great as that required at forty miles per hour. At sixty miles per hour, the distance required for stopping is four times as great as that required for thirty miles per hour. In addition, the number of times train signal indications must be observed and also the possible relative frequency with which brake applications may be called into action increase directly with the speed.

The objections to materially complicating agencies other than the air brake, for the purpose of protecting fast trains, have always been sustained and much attention, study and effort have therefore been constantly directed to this feature with the result that brake designs and apparatus have been kept and are available to the railways in advance of traffic demands. In operation, almost every attempt to provide improved power-brake mechanism has promptly developed the fact that the foundation brake gear, levers, rods, brake beams, etc., which are in service are usually not sufficiently strong to withstand the sudden strains to which it is subjected in emergency applications of the latest brakes. With the widespread use of modern steel passenger equipment cars in steam railroad service, a number of years ago the brake force required to control such heavy cars with approximately the same effectiveness as was obtainable with the apparatus used in lighter cars became so great as to exceed the capacity of a single brake cylinder and the greatest allowable multiplication of its power by leverage. The constantly increasing speed and weights of trains and the economy of time necessary for the greatest operating efficiency under competitive traffic demands, together with the increase in length of trains and the greater volume of air which must be handled through the brake-pipe imposed conditions which made the ordinary service functions and automatic safety and protective features of the brake apparatus hardly secondary to the compelling need of a high maximum emergency stopping power to insure the safety of passengers and equipment. Studies of the various phases of the general problem involved such considerations as—(a) Decreased brake-shoe coefficient of friction due to greater applied shoe pressures and speeds; (b) Possible breaking down of the brake shoe under the severe conditions imposed; (c) Increased brake leverage ratio, with consequent increased piston travel and lower maximum brake-cylinder pressure; (d) Increased foundation brake rigging deflection and false motion, where clasp brakes were not employed, due to severe stresses in the members, location of applied shoe pressure with respect to the wheel and other causes, tending to create false (increased) piston travel, increasing the time to obtain brake effectiveness on account of the larger cylinder volumes occasioned in this way and causing an unnecessary drain on the air supply when releasing and recharging; (e) Amount of unbraked locomotive weight; (f) Increased train momentum and (g) greater frequency and density in train movement.

Trains scheduled to run at high speeds are necessarily limited in respect to their weight and length, while powerful motive power is required to haul them. It thus occurs that the weight carried to the rails by the engine truck and trailer truck of a locomotive may be equal to seven per cent of the weight of the whole train (locomotive and cars combined). Failure to provide means for braking any wheels in a train detracts from the stopping efficiency of the brakes and this must ever remain first consideration in high speed service.

The Toledo and Absecon Trials

The result of the meeting of the Master Car Builders' Association Committee on Train Brakes and Signal Equipment of July, 1909, already referred to, was to approve the provision for a very extensive and elaborate series of tests. These were run on the Lake Shore and Michigan Southern Railroad at Toledo, Ohio, in the fall of that year, which involved the High Speed Brake, the LN equipment, and finally the PC equipment. The latter equipment proved eminently satisfactory as far as air handling devices were concerned by these tests resulted also in finding that foundation brake rigging equipment as then used was not adequate and improvements along that line were also initiated. A full report of this investigation is contained in the 1910 proceedings of the Master Car Builders' Association. The PC brake maintained brake cylinder pressure irrespective of piston travel and brake cylinder leakage by taking the pressure supply from the supplementary reservoir on each car and not from the brake pipe direct.



Type K Triple Valve, 1905

2	Body	15	Check Valve
3	Slide Valve	17	Union Nut
4	Main Piston	18	Union Swivel
5	Main Piston Ring	19	Cylinder Cap
6	Slide-Valve Spring	20	Graduating-Stem Nut
7	Graduating Valve	21	Graduating Stem
8	Emergency Piston	22	Graduating Spring
9	Emergency Valve Seat	29	Retarding-Device Body
10	Emergency Valve	31	Retarding Stem
12	Check-Valve Spring	33	Retarding Spring
13	Check-Valve Case	35	Graduating-Valve Spring

During July, 1913, a meeting was held to determine what had been accomplished in service as to the value of the PC brake. This resulted in a simplified equipment known as the UC which was then developed and tested out at Absecon, N. J., on the Pennsylvania Railroad in the Spring of 1913 and for a number of years has been the standard passenger brake equipment on all railroads operating modern trains. The UC equipment works in harmony with older equipments and its principal features are its certainty and uniformity of service action, not sensitive to slight fluctuations of brake-pipe pressure, very sensitive to desired release, graduated release (which may be cut in or out as desired) improved quick recharge, quick rise in brake-pipe pressure during release, quick rise in brake-cylinder pressure during emergency, maximum practicable difference between service and emergency braking force, service and emergency features are separated, full emergency braking force obtainable at any time, regardless of service applications previously made, full emergency application automatically made when brake-pipe pressure falls to a certain point and universally adaptable to any passenger service.

Description of Modern Air-Brake Apparatus

Before undertaking a discussion of the effect of modern traffic requirements on the development of the air brake, the following outline of the equipment in present-day use will assist the reader in a visualization of its essential features.

The modern air brake consists of:

a—Air pump or compressor on the locomotive,

b—Main reservoir or storage volume on the locomotive.

c—The engineman's brake valve, whereby the engineman controls the brake operation.

d—The brake pipe, or continuous pipe running throughout the train, connected between the cars by flexible hose and couplings, which constitutes the medium for air supply and brake control.

e—The triple valve, located on each car, so called because of the three functions of charging, applying, and releasing the brakes which it performs automatically in response to changes in brake-pipe pressure.

f—The auxiliary reservoir or storage supply volume on each car.

g—The brake cylinder on each car, the piston of which is connected, through suitable levers, to the brake shoes.

Passenger-car brake refinements are:

a—A supplementary or emergency reservoir under each car, furnishing additional storage volume, whereby the functioning of the valve brings about (1) high brake-cylinder pressure in emergency application, (2) graduated release, allowing brake-cylinder pressure to be exhausted in steps, and (3) quick recharge of auxiliary reservoirs.

b—Other detail modifications in the valve structure which permit (1) increased certainty of securing quick emergency action when desired without possibility of undesired quick action, (2) quick action emergency if for any reason brake-pipe pressure falls below a predetermined point, and (3) increased certainty and flexibility of brake in applying and releasing in service operation.

Freight-car brake refinements for long trains are:

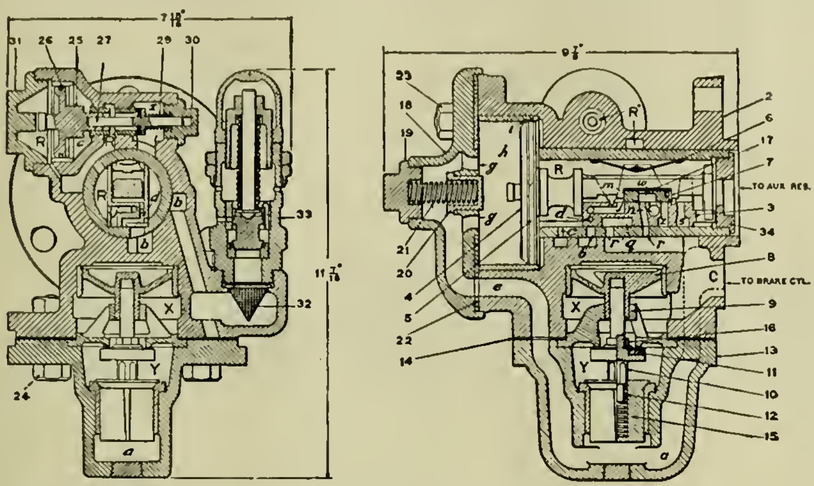
a—Quick-service feature, whereby the brakes in ordinary service braking are made much more prompt and positive in application.

b—Uniform or restricted recharge feature, whereby the auxiliary reservoirs on the head and rear ends of a long train are antimatically permitted to recharge in more nearly the same time than heretofore possible.

c—Uniform or retarded release feature, whereby the exhaust of brake-cylinder pressure on the head and rear ends of long trains is accomplished more uniformly.

Influence of Modern Traffic Conditions

The standard triple valve, for freight service, has been steadily improved and is today a very refined, as well as, successful piece of apparatus. It is called upon to charge, apply and release the brakes which it performs automatically in response to changes in brake pipe pressure. It requires for its successful manufacture the best of talent, proper consistency of materials composing its structure and the greatest of care in testing to determine beyond a doubt, if all the conditions surrounding its assembly, lubrication and adjustment meet the specified requirements. All this is essentially necessary to insure a device that may be depended upon to perform the functions that a triple valve is called upon to accomplish, that of applying and releasing the brakes under the cars in all lengths



Cross-Section of the L-Type Triple Valve

2	Body	13	Check-Valve Case	25	Bypass Piston
3	Slide Valve	14	Check-Valve-Case Gasket	26	Bypass Piston Ring
4	Main Piston	15	Check Valve	27	Bypass Valve
5	Piston Ring	17	Graduating-Valve Spring	29	Bypass Valve Spring
6	Slide-Valve Spring	18	Cylinder Cap	30	Bypass Valve Cap
7	Graduating Valve	19	Graduating Spring Nut	31	Bypass Piston Cap
8	Emergency Piston	20	Graduating Sleeve	32	Strainer
9	Emergency Valve Seat	21	Graduating Spring	33	Safety Valve
10	Emergency Valve	22	Cylinder-Cap Gasket	34	End Cap
12	Check-Valve Spring				

of trains and in the face of widely varying conditions of maintenance, manipulation and climate. The longer the trains, the greater will be the shocks if the valves do not sensitively respond to varying brake-pipe reductions in order to insure the most rapid propagation of serial quick action.

Freight cars in general interchange more widely throughout the country and are subject to every known condition and hazard of railroad operation—rough handling, wrecks, wash-outs, sand storms, over mountain ranges with ice and snow, winter weather in the northern climates, across deserts with dryness and extreme heat, set out idle for long periods without any operative function of the air brake mechanism being required. So it may easily be claimed for freight car brakes that not another piece of mechanism known to the railroad mechanical world is subjected to such extreme changes and conditions and also to perform as delicate and important a service as the triple valve.

Length and Weight of Trains

The reason for most of the changes in brake equipment has been the growing length and weight of trains, and in addition, the air consumption per car became greater and the head cars had more tendency to bleed the brake-pipe of air as fast as it was supplied, with the result that the forward end of the train was released and almost recharged before the rear end started to release. Modern standard brake equipments, in passenger service, employ a supplementary reservoir, which is used for recharging the auxiliary reservoir during the release of the brake and for obtaining high brake cylinder pressure in emergency applications. So far as the present standard freight brake equipments are concerned it is a well known fact that the high pressure in the head end of the brake-pipe of a long train, when releasing the brakes, causes the release of the head brakes to be retarded so that the rear brakes, starting later to release in the cycle of brake operation from head-end to rear of train, complete their release in practically the same time thus preventing the forward end of the train from fully releasing when a release of the brakes is made prior to a complete stopping of the train.

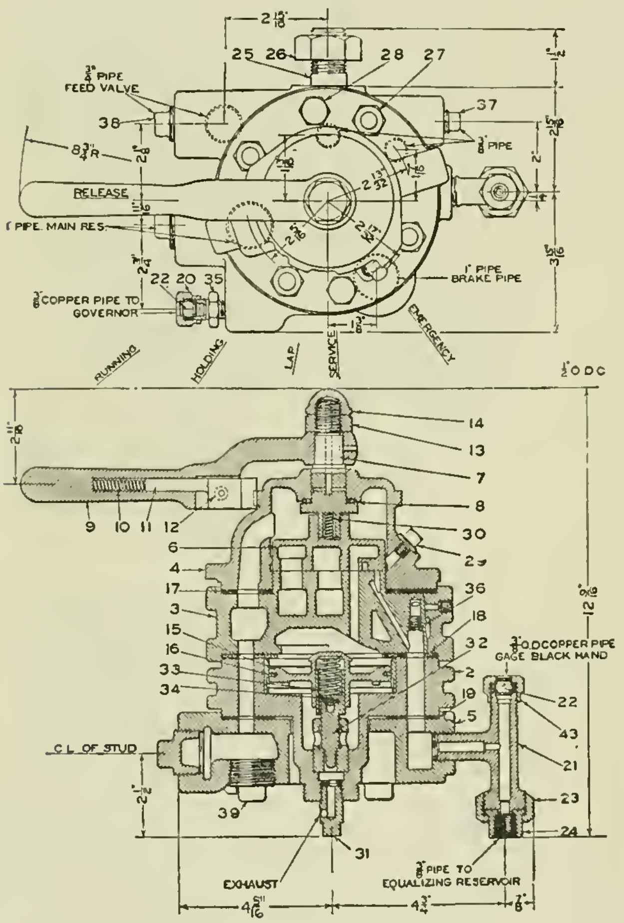
In the beginning 3 to 4 car passenger trains were standard while today trains containing 15 to 20 all steel cars are not the exceptions. In freight service 15 cars to the train used to be considered a good average load while today tonnage trains having well beyond 100 cars are a common daily occurrence throughout the country. So far as train weights are concerned these have increased, within the period of knowledge for most of us, from 500 to 1200 tons in passenger service, while in freight operation, we can consider the range as being from 800 to 8,000 tons. Since the first brake equipments were put out sixty years ago a genuine effort has been consistently made to improve braking conditions and operation, and in all this time nothing has been put out for adoption of the railroads, by the brake companies furnishing standard equipment to steam railroads, that would not operate safely and satisfactorily with devices previously supplied. This interchangeability in transition has been carried to the detail parts of devices themselves, so that many of the structural details of present standard apparatus are identical with the parts supplied for a great many years past, thus saving vast expenditures to the railroads, avoiding confusion, and risks of errors have been held to a minimum.

Density of Traffic

The increased density of traffic has made for somewhat greater frequency of movement even though this has been very largely offset through greater concentration of tonnage per car and per train. With longer and heavier trains, it has been necessary to secure brake action, both in applying and releasing, as rapidly and as efficiently as formerly. This calls for reliability, flexibility and effectiveness. The effectiveness of equipment for the control of trains determines the speed and number of trains which may with safety be permitted; it also governs the number of cars which may be successfully operated in each train, as well as their weight and variation in weight from the empty to the loaded condition. The ability to move trains hinges upon the reliability and certainty of their control under all conditions of operation. As advantage is taken of advancement in operating practice through a complete realization of the available potential value, rather than the mere necessity of improved maintenance, proper manipulation and full provision of the latest improvements in standard brake designs and materials, it will become fully evident that these features make possible the transportation of larger output where required and thus meet modern traffic demands which, as is well known, become constantly more intensive. It is not enough that safety be had from available standard brake apparatus. This also can be obtained in conjunction with greater economy in operation as a whole and provide greater railroad capacity. The extent of evil results arising from any lack of the most intelligent provision for suitable material and labor for maintenance and proper supervision and instruction for manipulation practices on the part of those immediately concerned, is not always within the vision of those to whose interest it is to know of these limiting factors for best railroad management, if inadequately administered and not diligently supported by the chief administrating officers.

The Locomotive Brake

The present standard locomotive brake furnished is a much more flexible and effective brake than was formerly provided, having due regard to the steadily increasing size of motive power. The distributing valve which performs the triple valve function and a number of others, in this brake equipment, is the same irrespective of the size of locomotive, and in conjunction with this feature of having but one valve for all sizes and classes of locomotives, there appears the feature of brake cylinder pressure maintenance irrespective of piston travel or brake cylinder leakage and the air for supplying the brake cylinder is taken directly



Latest Engineer's Brake Valve

2	Body	16	Piston Ring
3	Rotary Valve Seat	17	Upper Gasket
4	Top Case	18	Middle Gasket
5	Pipe Bracket	19	Lower Gasket
6	Rotary Valve	21	Gage Equal. Res. Tee
7	Rotary Valve Key	30	Rotary-Valve Spring
8	Key Washer	31	Exhaust Fitting
9	Handle	32	Valve
14	Handle Locknut	33	Valve Spring
15	Equalizing Piston		

from the main reservoir. Great flexibility of control is provided in the present standard locomotive brake equipment in permitting the locomotive brakes to be handled either in conjunction with or independently of the train brakes.

Development of the Triple Valve

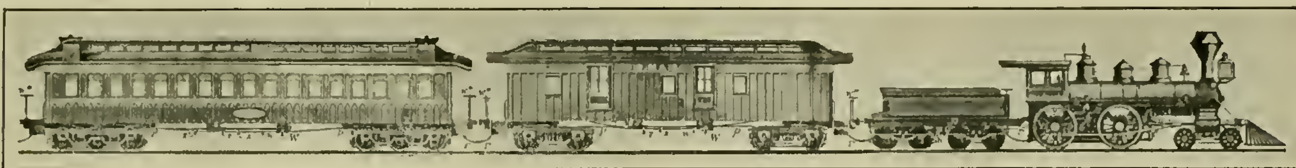
Much work has been done with respect to passenger car brake equipments with a view of caring for the proper handling of heavier cars, longer trains, greater strictness of schedule compelling better acceleration and deceleration, as well as higher average speeds. The PC equipment which was developed prior to the U.C. type, had the so-called compensation feature, which provided for maintenance or supply of brake cylinder pressure against leakage and irrespective of variations in piston travel, taking air for this purpose from a supplementary reservoir on each car. Aside from basing the design of the U.C. equipment to work in all classes of service and furnish ready means for adding, without other modification, new features, such as electrical control in the future it was decided to eliminate the brake cylinder maintaining feature, formerly embodied in the P.C. type of construction, because there was found to be no practical benefit in maintaining cylinder pressure against leakage, if the piston packing cups were in good condition, as there is no function of supplying air on a differential in pressure less than approximately three pounds, and this appeared to be greater than the average leakage which should take place in the time required to make a stop. Piston travel was largely regulated through the provision of clasp brakes, consequently the need for this provision of the P. C. equipment was deemed an unnecessary complication for modern rolling stock.

Uniform and instantaneous application and release of the brakes are the distinctive features which have governed the efforts put forth in the design and construction of air brake apparatus. Automatic air brakes are operated by differentials of pressures originating, in normal operating train service condition, at the head end of the train through the manipulation of the triple brake valve, and as trains have advanced in length the engineer's brake valve has been improved in design and construction to meet the changed conditions. One important experience became imperative of solution as train lengths increased and having regard to the distance the air had to travel to reach the exhaust at the brake valve and this was the effect of the friction in the brake pipe, couplings, etc., in conjunction with the volume of air which had to be handled on these long trains which increased the time of securing the differential in pressures required to such an extent that when the entire differential was created at the brake valve, the application of the brakes would be completed on the head end of the train so long in advance of any adequate effect at the rear end that the slack would run in so violently, when making a stop, that destructive shocks occurred during heavy applications of the air brake. This immediately focused attention on the need of having the triple valves on each car assist in making the serial action of the brakes throughout the train rapidly enough to avoid shocks. Thus, when the quick action triple valve was placed in service, it furnished a needed element, namely, local brake pipe reductions, which resulted in cutting down the time of serial application of brakes in emergency only by making such pipe reduction on each individual car.

The present operating conditions with trains of still greater length and up to 150 cars, necessitated a still further decrease in time of serial application of brakes through the train in normal manipulation, that is in making regular stops, not in emergency, as was done with the H type Quick action triple valve, which as was explained, was confined to emergency applications only.

In the same manner, the shocks to trains resulting in damage to equipment and lading during release of brakes with the H type triple valve, owing to earlier release of triples on head cars in a long train to such an extent that it was necessary to require enginemen to complete the stop after once making a brake application, rather than attempt to release the brakes at slow speeds. This resulted in the provision of the uniform release feature, of the present standard freight brake equipments, to compensate for this difference in time of release, so that a release of the brakes could properly be made at any time desired.

The present long trains also bring a demand for more uniform application of brakes as to pressures, making it necessary to have uniform recharge of auxiliary reservoirs. The longer trains, with additional brake pipe volume, pipe friction and leakage in piping and couplings, make it increasingly difficult to obtain rise of pressure in break-pipe at rear end of train with sufficient rapidity to insure release of all brakes when older classes of brake equipment with H type triple valve were used. This resulted in the development of the type "K" triple valve which first began to come into general use in 1909 and in 1911 after demonstrating to the satisfaction of the Master Car Builders' Association, that this valve possessed fundamental features of improvement not common to former valves, namely, quick service, retarded or uniform release and uniform recharge, that body adopted it as standard for all cars used in interchange. The work was carried out in such a way that all improvements in equipment could be added, if desired, to the standard quick action or H type triple valves already in use and also in such a way as to improve the operation of the older equipment when used on trains in association with the newer type.



Passenger Train About 1872

The Empty and Load Brake

It is well known that the braking force provided by the standard single capacity brake is constant, and consequently less flexible or effective for use when a car is loaded which results in non-uniformity of braking force in trains composed of loads and empties and, in special cases, it has been found that there was inadequate braking force in loaded trains operating in special service. The empty and load freight brake equipment overcomes this difficulty by providing a varying braking force to suit the widely varying operating conditions. It is a double capacity brake, equally as effective when the car is loaded as when it is empty. This is accomplished by the use of two brake cylinders, one being operated when the car is empty and both when the car is loaded. With regard to passenger service where train speeds are high, safety is of greater importance than for freight train service where train speeds are lower. Considering the limits of vision of the engineman and under the same conditions, the need for brake effectiveness on a passenger train as compared with a freight train varies in proportion to the squares of the speed of the two trains. If the passenger train is running twice as fast as the freight train the braking effectiveness required to provide a suitable stop in comparison is four times that of the freight train.

With present equipment, under critical conditions of train speed, train length, train consist as to loads and empties, draft gear condition, track curvature and grade, emergency brake action is often too severe and sometimes results in damage. The running in of train slack is apt to be violent in proportion to the serial time of brake action throughout the train and in direct proportion to the brake cylinder pressures obtained. This is the reason for not considering any attempt to increase emergency brake cylinder pressure in freight service without at the same time refining the time element of serial action since greater damage to cars and lading would inevitably be experienced unless this was done. In other words a shorter stopping distance would be obtained at the expense of added risk of damaging internal collisions and injury to train crews.

While the make-up of trains enters largely into the problem of retardation, aside from any question of braking ratio, in that empty trains develop more train resistance, for equal weights, than loaded trains, still as the average carrying capacity and loading per unit of equipment, composing a train is increased, the less will be the train resistance per ton weight composing it. In the matter of determing the tonnage which may be safely taken from the top of a grade to the foot of the same, we find it is limited by the speed, actual braking percentage of gross weight of train, effectiveness of the brakes and the ability to keep them recharged. The number of cars per train must, of necessity, be limited for the reason that each unit added to a train increases the time required to fully recharge the brakes between applications. This increase in recharging time is the result of the larger volume of air to be restored to the brake pipe and auxiliary reservoirs, the greater volume of air lost through leakage, and the increased frictional resistance to the flow of air to the rear end of the train. The limits on the gross weight of car per brake and number of cars per train are both materially influenced by the effectiveness of the triple valves in performing the functions of recharging and applying all brakes uniformly and promptly, besides developing the required retarding force with comparatively light brake pipe reductions. This is the principal practical value for maintaining air brake apparatus in the most perfect physical condition possible, and using, for replacement, only standard materials known to be properly manufactured by the brake manufacturers. A braking system, to be highly successful, must be capable of maintaining the train constantly under a control which not only provides against loss of life, but also protects the equipment and lading in the train from damage, in the face of any situation which reasonably may be expected to arise. This calls for an available braking force in reserve and ample to permit any train to be stopped on the heaviest part of the grade, within a reasonable distance, from running speeds which are held within proper limits.

Economic Advantages of Air Brakes

Fundamental to air brake development there has remained one constant guiding principle, namely, to make the best possible product devised to be as simple and as automatic as circumstances would allow, also as foolproof and reliable as possible, all with the purpose of providing for the least necessity for required maintenance. The problem has further been approached from the standpoint of making every piece of mechanism turned out for standard equipment work in harmony with every other piece, whether the same may have been of late or early design.

The value of train braking is twofold, first, the function of being able to stop in the shortest possible distance when necessary, and second, to permit short, effective, smooth and accurate stops in regular operation, because the brake is not only a safety device but one having a real influence on efficient handling of trains, permitting the hauling of heavier cars and longer trains, and makes possible faster and more frequent service, as much or more than does the locomotive or any other known means.

To further appreciate the importance of the power brake in connection with the advance in the science of railroading, we need only examine the development and the growth of both motive power and rolling stock in the period from the first application of power brake (1869) to the present, as tabulated below.

Locomotives

	1869	1925	Increase
Weight on Drivers	25,000 lbs.	400,000 lbs.	16 times
Tractive Effort	10,000 lbs.	100,000 lbs.	10 times
Total Weight		700,000 lbs.	..
Working Steam Pressure	125 lbs./sq. in.	225	1.8 times

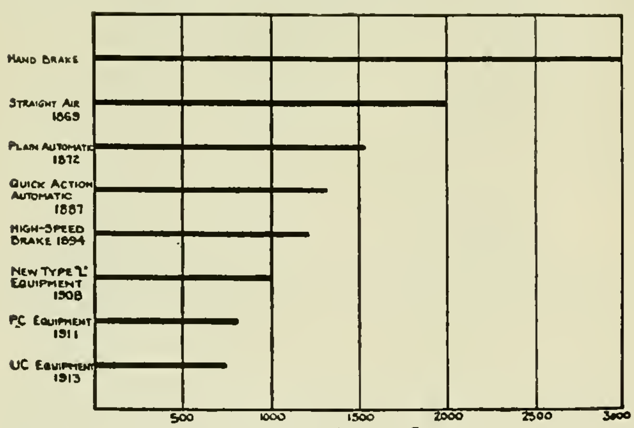
Passenger Cars

	1869	1925	Increase
Weight	20,000 lbs.	150,000 lbs.	7.5 times
Speeds (Pass. Train)..	30 m.p.h.	65 m.p.h.	2.17 times

Freight Cars

	1869	1925	Increase
Light Weight	12,000 lbs.	50,000 lbs.	4.17 times
Capacity	40,000 lbs.	150,000 lbs.	3.75 times
Cars per Train	15	130	8.67 times
Tons per Train	300	6,000	20 times

For efficient transportation, it is not only necessary to provide enough power to move the maximum tonnage trains, but it is equally important to keep such a train under control within the permissible speed and bring it to stop when necessary. Starting and stopping of trains are complimentary factors in the problem of meeting operating schedules between stations and many times only the starting factor is given full consideration, or at least, the one more carefully provided for. This all important factor of stopping and its increasing difficulty in face of heavier trains and higher speeds can be best understood when interpreted in terms of the power required to stop a light train at low speeds as compared with a heavier train at high speed. Energy contained in a 5-car train with cars running at a speed of 35 miles per hour equals 6,200,000 foot-pounds, whereas for cars having an average weight of 172,000 pounds, running at 65 miles per hour, it is 90,000,000 foot-pounds, or nearly 15 times greater. However, the improvement in the air brake



Progress of Air-Brake Efficiency as Shown by Comparative Distances in Which Trains Are Stopped

equipment has more than kept pace with the increased load per car and number of cars per train.

The total maximum force exerted by the push rod of a 6-inch brake cylinder is only 1,700 pounds while with the 18-inch brake cylinder rod under the heaviest coaches is 26,670 pounds or almost 16 times greater. The tremendous power required to stop a moving train is peculiarly significant when it is realized than an ordinary "Pacific" type locomotive with a train of 11 all steel cars will attain a speed of 50 miles per hr. in about 23 minutes, covering a distance of about 80,000 feet, while in stopping from the same speed it only requires one-half of one minute and a distance of no more than 1,000 feet. In other words, the rate of retardation is about 1.6 miles per hour per second. Roughly speaking, the force for acceleration, same as retardation, is about 100 pounds per ton at the rate of one mile per hour per second. Thus, if we were to have the acceleration of the same train to approach its retardation by the power brakes, or 1.6 miles per hour per second, we would require a locomotive to develop a constant tractive effort, from starting to 50 miles per hour, of 176,000 pounds, or 6 "Pacific" type locomotives coupled together at the starting and increasing to 13 locomotives at 50 miles per hour.

The power brake, in its development, has not only met the requirement for furnishing a tremendous power for braking, but also for applying the power in the most efficient manner, as to constantly shorten the necessary distance in stopping a moving train. In conclusion, it may well be added, that it is the power brake which makes modern transportation possible in the safest and most efficient manner, not only this, but it precedes the utilization of heavier motive power and rolling stock operated on frequent and exacting schedule, as now maintained.

C. B. & Q. R. R. Powerful Gas-Electric Cars

Eight of the most powerful single-unit gas-electric railway cars ever built will be used by the Chicago, Burlington and Quincy Railroad as a part of the large fleet of these vehicles being built up by that railroad. A total of 53 gas-electric cars is so far involved in the program.

Early in 1927 five gas-electric cars were placed in service by this company. In the middle of the same year eleven more were added; and an additional 36, now being built, will be in service by September.

The new and unusually large power plant with which eight of the latest cars are equipped represents a marked advance in the development of internal combustion engines for railway use. Each car is equipped with a 400-horsepower, model 148, eight-cylinder Winton engine. The engine drives an electric generator supplying power to two 220-horsepower motors on the front trucks. A total of 400 horsepower is thus available from the power plant, whereas the maximum available power from a single car heretofore has been from 275 to 300 horsepower.

The electric transmission equipment for 28 of the new cars is being built by the General Electric Company. All of the earlier cars, with the exception of one, have Electro-Motive Company standard 275-horsepower Winton engines driving General Electric generators which supply power to two 150-horsepower motors on the front truck of each car. Drum-type control is used for single-end operation. The new cars with the 400-horsepower engines are provided with single-end remote control. The one remaining car has two Mack International Company 135-horsepower gas engines, with General Electric generators and 150-horsepower motors. Control is of the remote magnetic type.

Gas-electric drive was chosen for this service by the Burlington because of the saving in operating and maintenance expense, as well as increased reliability. It has been demonstrated that this saving with the use of gas power is from 40 to 60 cents a train mile. The 65-foot cars are normally operated in two-car trains, the second car being a light 35-ton coach or combination baggage and mail car. The 75-foot cars normally operate as a single unit. The 275-horsepower cars weigh approximately 50 tons, and the 400-horsepower cars 65 tons, loaded and equipped.

Triple Unit Gas–Electric Rail Cars

Triple Unit Power Plant Requires Little Space and Insures Dependable Power

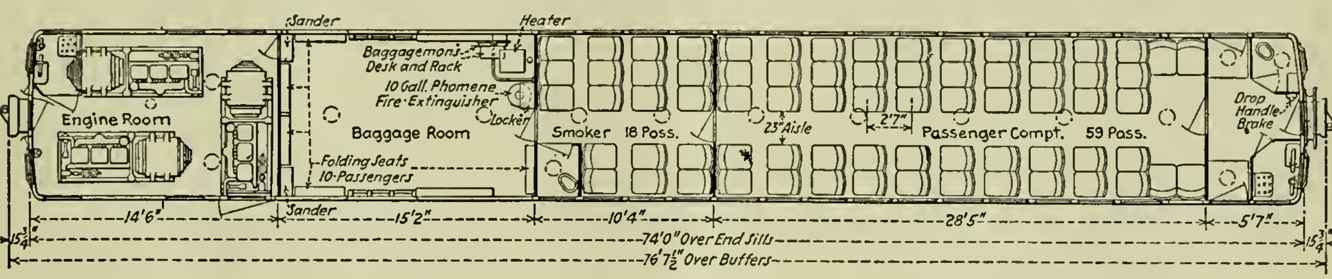
The first triple-power-plant gas-electric rail car has been completed and tested satisfactorily. It was built for the Reading Company by the Mack International Motor Company, Plainfield, N. J. It is the builder's model AR car and it is the first one ever equipped with the combination of three power plants.

In developing the triple-power-plant Mack rail car, the International Motor Company continued its policy of using a standard power unit and varying the number of power units according to the service application. By this arrangement, a single stock power unit equipment provides for all applications. In addition a multiple power plant equipment is considered much better protection against car failures resulting from an engine failure and the feature of stopping an engine whenever desired is a matter of excellent economy. The power unit itself is easily removed, compact and accessible.

In such a multiple power plant arrangement it was found desirable to arrange the equipment so that it could be controlled remotely and be multiplied with other cars. spaced bus type seats. The main compartment has seats deeply upholstered with plush, while leather is used for that purpose in the smoking compartment. These seats are shock insulated from their floor mounting, which also makes them more flexible and yielding to an occupant's weight. This comfortable arrangement, accompanied by generous lighting, gives the passenger compartments a parlor car aspect.

The car is heated by a pressure-hot water system. The heater is located in the baggage compartment and is arranged for connection to the engine cooling system without relieving the pressure on the radiators or putting on the engines.

To add to the further comfort and safety of the passengers, the trucks are equipped with clasp brakes. The trucks are the cast steel two-axle equalized type built by the Commonwealth Steel Company. The forward truck carries two of the three traction motors, while the third motor is mounted on the forward axle of the rear truck. The car wheels are 36 in. in diameter and are mounted



General Arrangement of the Reading Company's Triple Unit Gas-Electric Car

The Reading triple-unit car is arranged for operation from a trailer as well as from either end of the motor car. This feature is incorporated in the control scheme.

In addition to the multiplying arrangement there are three automatic features. The first is the automatic battery O charging from the main generator during engine idling, which fully protects the battery from an over-voltage from the main generator at all times. The second is the automatic loading of the engine by its own ability to carry its load, this is being independent of a condition to carry its load, this being independent of a condition such as the temperature of electrical or mechanical equipment and dependent wholly on engine speed. The third is the automatic shunting of the traction motor field at 37 miles per hour.

These power plants are so arranged that no blower motors are used in dual cooling systems of each power unit. This is accomplished by utilizing the exhaust gases through eductors and in turn diluting the gases with a large quantity of air.

The car was built at the Paris, Ill., plant of the Cummings Car and Coach Company. The over-all length, buffer to buffer, is 76 ft. 7½ in., the weight is approximately 60 tons. A space only 14 ft. 6 in. long is required for the engine room. This is largely due to the compactness of the power unit, the length of which is 96 in. overall. This leaves a large percentage of the body available for revenue service, as no valuable space is sacrificed in providing an operating compartment at each end for the double-end operation.

The passenger compartment is equipped with well on A. E. R. A. E-10 axles which have 5½ x 10 in. journals and 7 in. motor bearings. The rear truck center is 11 ft. 8 in. from the rear end sill while the front truck is but 6 ft. 6 in. from the front end sill. This tends to give best weight distribution with the power units at the front of the car.

Each power unit consists of one Mack model AP engine, one Westinghouse type 180-A-4 generator, one control equipment, one 12 cu. ft. air compressor, and one charging generator all mounted on a light-weight bedplate.

Each power unit weighs approximately 5,000 lb. without the control equipment and the expansion tank.

The prime mover is a standard Mack gasoline engine of the vertical, four-cycle, high-compression type designed for continuous duty. The design is such that excellent economy is obtained over a wide range of engine speeds. It has six cast *en bloc* cylinders and uses three removable heads, large poppet intake and exhaust valves, one of each for a cylinder, arranged at one side of the block. The parts are primarily those used in the other Mack vehicles.

General Dimensions of Mack AP Engines

Bore and stroke	5 in. x 6 in.
No. of cylinders	6
Piston displacement	707 cu. in.
Governed speed	1350 rpm.
Piston speed at governed speed	1350 ft./min.
Horsepower at 1350 rpm	124
Horsepower delivered to generator at 1350 rpm	120

The generators are of special construction and designed around the characteristics of the engine. They are so built with proper speed and rating margins that the engines are correctly loaded for the entire operating range of the car. The particular features of the design are high efficiency, high ratings, engine cranking from generator and battery charging from the same source during idling periods. These machines are not equipped with exciters or differential fields for power output regulation. Instead, there are three fields; a battery tickler field, a high voltage shunt field and a series field for starting the engine and charging the battery. The tickler field is used at all times, the shunt field is used during power periods and is regulated externally, and the series field is used only during starting and charging periods.

The leads from each main generator are carried up to the small control cabinet mounted directly above the generator. During power periods each generator is connected through these panels to the Westinghouse Type 559-D-2 traction motors. There is no inter-connection of generator or traction motors as each generator drives its own motor. The traction motors are also of special design for gas-electric cars. Their particular features are high efficiency, low speeds at the continuous rating together with high safe speeds, and the ability to efficiently take the full engine-generator output over the operating speed range of the car. The motor ratings are the same as those of the generator; that is, the Type 180-A-4 generator and the Type 559-D-2 motor are of balanced design. This removes a large part of the desirability of series-parallel operation and enables field shunting to be substituted without additional complication; high-speed loading is achieved as a direct result.

These traction motors incorporate a number of specific features. Among them is an arrangement of brush holders which reduces flashover tendency. This is accomplished by using four instead of two brush-holders and locating those of like polarity at opposite points on the commutator. Bouncing of the armatures on crossings and rough track, which causes the majority of flashovers, is minimized as the points of contact are doubled and the tendency for the commutator to bounce clear of a brush will automatically compensate on the other brush of the same polarity.

The usual standard of waste-packed traction motor bearings and axle bearings is followed.

Control

The method of controlling this combination of motor and generator is distinctly new in rail car service. The general method of handling the power circuits, starting the engines. etc., follows the usual gas-electric standard for Westinghouse equipment but the method of regulating the output is entirely new. It is built up on the fact that an engine's ability to accelerate under a given load is a direct indication of its ability to carry that load. Consequently the engine governor is equipped with a set of special contacts. The governor is set slightly in excess of 1350 r.p.m. and any tendency on its part to operate and close the throttle causes a pair of these contacts to close and any tendency of the governor to further open the throttle, as it would if the speed dropped below 1350 r.p.m., causes the other pair of contacts to close. This pair of operations controls a small motor and causes it to run in one direction or the other depending on the contact established. This motor operates a rheostat in the shunt field circuit of the main generator and varies the loading placed on the engine by this generator. Thus it is seen that the engine actually loads itself for constant speed regardless of condition and will do so regardless of the temperature of the electrical equipment. This method of loading is the first application of this type of control. The regulating unit which includes the reversible motor drive, rheostat, and traction motor field shunt is the Westinghouse type UD-2 motor operated faceplace. It is a complete unit and is mounted above the generator and back of the control panel.

The control apparatus is of the standard Westinghouse 32-volt electro-pneumatic type. Several features are incorporated in this, including electro-pneumatic throttle control and electrically operated sanders. A special "link-in" feature permits overloading the engine when running as low as 1200 r.p.m. at 50 mph. This is an economical feature. The previously mentioned automatic field shunting and battery charging from the main generator are also noteworth. The automatic field shunt is particularly helpful in protecting the equipment as well as further improving economy. The battery charging from the main generator is automatic. The battery is entirely protected against over-voltage by a relay across the terminals of the generator.

The main generator is not the only source of battery charge as there is a 750-watt charging generator on each power unit. By distributing the charge over running and idling periods it is possible to dispense with all lighting and charging regulators.

With the exception of sanders and control stations all control equipment is mounted on the power unit and is included as part of the removable power unit equipment feature. Knuckle joint connectors are provided for the main circuits to the power unit and a flat type jumper and receptacle for the control circuits in order that the electrical circuits may be disconnected easily in case a power unit is to be removed from the car.

The centralized control stations at each end of the car combine all of the control equipment including sanding, reversing, engine starting and stopping and car power control. They are of compact design and unusually accessible, using a number of parts in common with other control equipment on the car.

The Trail Car

The trail car built for operation with either the Mack triple power plant rail car or a Brill double power plant rail car is also of novel construction. One end is equipped with a Westinghouse-Mack control station and the other with a Westinghouse-Brill control station. Suitable jumpers and receptacles are provided for carrying control circuits between motor car and trailer.

An Oil-Electric Locomotive for Road Service

The first oil-electric locomotive intended for road service has been built for the New York Central Railroad by the General Electric, American Locomotive and Ingersoll-Rand companies.

Oil electric-locomotives, first announced in this country in 1924, use an oil engine to drive an electric generator. The electricity is fed to motors which drive the locomotive. Oil-electric locomotives have been built and installed for various duties by the three companies, but none previously was designed especially for this type of service.

The new locomotive, weighing 145 tons, will replace steam locomotives now in freight service on the Putnam Division of the New York Central Railroad. It has sufficient capacity for handling freight trains of the weights common on this division—from 500 to 550 tons—and will maintain the same schedule as the steam locomotives.

The cab is divided into three sections, including a main apparatus cab and two operating cabs. The main cab contains the power plant, consisting of the engine-generator set, together with contactors, switches and other apparatus for controlling the machinery. In this cab also are installed the fuel and water tanks, and the air compressor for starting the engine. At one end of this cab is a radiator for cooling the circulating water from the engine. Two fans, located near the floor, force cool air through the tubes of the radiator and discharge hot air through the roof of the cab.

The operating cabs are located at each end of the locomotive. Each contains an engineer's seat and, within easy reach, handles for the air brake and controller, and a number of push buttons for controlling the auxiliaries.

The oil engine is a four-stroke, six-cylinder, Ingersoll-Rand engine of 14¾-inch bore and 16-inch stroke. It develops 750 horsepower at a speed of 500 r.p.m. It is of the solid-injection type, fuel oil being delivered to the cylinders by a pump driven by the engine. The oil goes through a distributor which is timed to register with the power stroke of each cylinder.

The General Electric equipment consists of main and auxiliary generators, four traction motors, the necessary control for the operation of the locomotive alone or in multiple with another locomotive of the same type, and electric auxiliaries, lights and meters. The traction motors are the same type as used on the Type Q switching locomotives of the New York Central Lines. These motors will develop, at their one-hour rating, a tractive effort of 30,600 pounds, and a tractive effort of 20,800 pounds at their continuous rating. Maximum tractive effort is developed by the motors for short periods of time up to the slipping point of the wheels. The motors may be operated in various electric combinations by means of electro-pneumatic contactors controlled by the reversing lever on the master controller.

Compressed air for the brakes is furnished by a motor-driven air compressor. The circuit is maintained for the lighting and control circuits by a 32-volt, 135-ampere-hour storage battery which is maintained in a state of charge by a motor-generator set. In ordinary operation the lighting and control circuits will be supplied direct by the motor-generator set instead of from the battery, the latter floating on the line.

The locomotive is provided with cab lights in both operating and engine compartments. Drop lights are also provided in the engine compartment. All lights, including headlights, are connected to the 32-volt circuit. A dimming resistance is provided for each headlight.

Meters are located on an illuminated gauge panel at each operating station. Train line jumpers and sockets at each end of the locomotive permit coupling two or more locomotives in multiple, and controlling the operation of both from a single operator's position. The principal dimensions and data of the locomotive:

Oil-Electric Locomotive for Road Service

Rating of oil engine	750 h. p.
Motor equipment	Four GE-286
Weight on drivers	175,000 lbs.
Weight complete	295,000 lbs.
Length inside of knuckles	52 ft. 1 in.
Total wheel base	42 ft. 10 in.
Rigid wheel base	17 ft. 6 in.
Truck wheel base	6 ft. 2 in.
Maximum tractive effort (30%)	52,500 lbs.
Normal tractive effort	30,600 lbs.
Continuous tractive effort	20,800 lbs.

Heretofore, the oil electric locomotives in operation in this country have been used exclusively in switching service in railroad and industrial yards. The performance record of its service in passenger and freight service on the Putnam Division of the New York Central will be of interest. In Europe, and particularly in Russia and Sweden main line operation has been satisfactory. The performance of oil-electric motor cars would indicate that the maintenance of main line equipment will not be any more severe than that of switch engines.

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The Development of Power Brakes

One of the most interesting features of railway development is the story of power brakes. We never tire of the story of the "Iron Horse," and wax eloquent when comparing the "Stourbridge Lion," "John Bull," the "Iron Sides," "Rocket" and other pioneers with the ultra-modern engines such as the "Hudson Type," the "President Class," the "John B. Jervis" and others, and none can detract from the wonderful achievement these comparisons represent.

It is with well justified pride that we tell how boiler pressures have been increased from 50 to 450 pounds in the United States and that abroad as much as 850 pounds pressure is being experimented with. We are equally proud of our speed records that have risen from 10 to as high as 60 and 75 miles per hour and well authenticated spurts under special conditions where 100 miles per hour have been exceeded.

The power brake not unlike most all inventions, theories and innovations, the adoption of which involved departure from established custom or practice, at first met with no little opposition and much ridicule.

The Apostle Paul was so firm in his belief that he was right, that it was eight years after the Crucifixion of Christ and the imprisonment and death of scores of other Christians that he (Paul) was willing to admit that there was merit in the Christian religion. Then, he frankly confessed that he had been wrong all the time.

The fallacious theories of Dr. Lardner in regard to the use of steam power as applied to navigation retarded or set back the development in marine engineering twenty years or more. Long after practical engineers had overcome the barriers of Dr. Lardner's theories, he was reluctantly forced to admit his error and spent considerable portion of the remainder of his life trying to explain how he had been misquoted or that he really did not mean what he had been saying anyway.

It is related that when the late George Westinghouse first called on Commodore Vanderbilt to interest him in the use of an air brake to replace the hand brake then used, that the Commodore listened somewhat impatiently for a while and then exploded, as it were, with the rather caustic remark: "Young man, you must think me a fool to entertain a proposition to stop a railway train with wind!" Years later the Commodore much regretted what proved to have been a very rash remark.

And thus we might go on indefinitely with examples and the results from acts of commission and omission by those who have opposed human progress in its various lines of activity.

A review of the development of American railways without a history of power brakes would be about as complete as an alleged history of the United States without mention of George Washington. And when we write the history of power brakes we write the history of George Westinghouse, as the two are inseparable.

At the Spring meeting of the A. S. M. E., held in Pittsburgh, L. K. Sillcox, recently head of the mechanical department of the Chicago, Milwaukee & St. Paul Railway and at present assistant to the president of the New York Air Brake Company, presented a very comprehensive review of Power Brakes and Modern Train Operation, which constitutes a most valuable addition to our engineering literature on the subject.

Railway and Locomotive Engineering is glad to present to its readers an abstract of the paper referred to and which appears elsewhere in this issue. The historical facts, engineering and operating details and the illustrations there given will, no doubt, prove of great interest and value to those seeking information on the subject.

Mr. Sillcox in his very thorough and exhaustive manner has shown us the progress of air brake efficiency. His comparisons of the distances in which trains can be stopped under varying conditions gives the basis which explains why it is possible for us to now run about 15,000,000 trains annually or about 41,000 daily, with earnings of six and one-half billions of dollars annually and serving about 120,000,000 people. There is no one single factor or integral part of our great transportation unit on which the foregoing achievements are so dependent as on the power brake.

Boiler Design and Higher Steam Pressure

In our last issue we presented for consideration of those interested in steam boiler design certain points that have and will continue to receive much thought and study by engineers in the industrial, marine and railway fields. It is gratifying to note that other engineers have felt the urge to move forward too, particularly in the matter of higher pressures. The questions presented with respect to a possible revision of specifications for material used in boiler construction is of course of such vital importance that no immediate or possible hasty action will be taken, although there should be instituted and without delay such investigations and practical tests as will definitely determine the main points involved.

A recent contribution from an engineer of recognized authority on such matters, following an exhaustive review of the subject in its various phases, sums up with the suggestion that for flash type boilers pressures of 2,000 lbs. and higher will obtain, while for water level type boilers the pressures will range from 800 to 1,600 lbs., with temperatures of 750 degrees and that the life of tubes will be materially reduced, unless a much more expensive alloy steel is used in their manufacture.

With all our inventive genius, it would seem we cannot see very far into the future and particularly the possible strides that may yet be made in the engineering field.

Heavier Rail for Heavier Traffic

More than two-thirds of all the rail tonnage produced last year was in the one hundred-pound section or heavier, according to the American Iron and Steel Institute. For the fifth consecutive year the production of rails with a weight per yard of 100 pounds and over exceeded one million tons. The use of such rail has more than doubled in the past ten years.

Steel rails produced in 1927 totaled 2,806,390 tons, of which 1,931,948 tons weighed 100 pounds and over. This ratio, namely 68.84 per cent. is the highest ever reached. Of the total production in 1926, 61.12 per cent was 100 pounds and over; in 1925 the ratio was 58.76 per cent; in 1924 it was 48.31 per cent; and in 1923 it was 50.47 per cent.

The principal method utilized by railroad managers to produce more economical operation is by increasing the amount of tonnage moved in a single train. This means larger and heavier locomotives and bigger and more heavily loaded cars, plus more cars in each train. To provide a track which will stand up under the constant operation of such trains and which can be economically maintained requires heavier rail and more ballast.

While the total rail produced last year showed a decrease of 12.78 per cent as compared with the 3,217,649 tons produced in 1926, it was a gain of 8 per cent over the 10-year average (1917-1926), and near the average of 2,812,079 gross tons for the three years, 1924-1926.

Recognizing the preponderance of the extra-heavy rails, the American Iron and Steel Institute made for the first time last year a separate grouping of those rails weighing 120 pounds or more. Rails of this type totaled 617,524 tons representing 22.01 per cent of the entire production.

Just 13 years ago the 100-pound rails were separately grouped from the previous heavy classification of 85 pounds and more. This factor in itself is striking evidence of the development of heavier rail for heavier traffic.

The Greater Service of the Freight Train

Eight years ago a freight train moved ten miles an hour while it now moves 12.8 miles an hour, an increase of 27 per cent. During the same period the number of cars in the average train has increased from about 36 to approximately 48, or an increase of about 33 per cent.

However, it is important to note, from the standpoint of both railway earnings and operating expenses, that the number of empty cars in the average freight train has increased more than the number of loaded cars. This apparently has been due to the success of the co-operative efforts of the railways and the shippers in distributing cars in such a way that they will always be where they are needed. In order to accomplish this it seems necessary to always move relatively more cars when empty than formerly.

Eight years ago the average freight train contained only ten empty cars and 26 loaded cars. Now, it contains about 17 empty and 31 loaded cars. There has also been a decline in the average number of tons of freight in each loaded car. Despite the fact that there has been a decline in the load per car and an increase in the number of empty cars per train, the freight train renders much more freight service than formerly, because of its increased speed and length.

Eight years ago the hourly service of the average freight train was equivalent to carrying 7,440 tons one mile. Now, it is equivalent to carrying 9,915 tons one mile, the increase being about 33 per cent.

Traveling at an average speed of 13 miles per hour, all the freight trains in the United States move an average distance of about 1,675,000 miles. This is equivalent to 70 trains going around the earth daily or 560 moving from New York to San Francisco daily.

Allowing for the changes in prices and wages that have occurred since before the war the average freight train today is a more economical, speedy and efficient means of handling the commerce of the country than it ever was in history.

Locomotives in Suburban Service

By ARTHUR CURRAN

The problem of handling suburban traffic has been solved in several American cities by the electrification of terminal stations and the trackage that is tributary thereto.

The success of these installations has led to a considerable amount of heated agitation for their duplication elsewhere.

Now, it may be admitted that, under the right conditions, the multiple-unit train constitutes an ideal answer to the demand for rapid transit in congested areas. Moreover, during the past twenty years much progress has been made in the field of electric traction; enough, at any rate, to eliminate most of the technical difficulties which at one time troubled all who were concerned with electrification.

It is the financial problem which still defies solution in certain localities, and which is likely to prevent any extensive work along electrical lines for many years to come. In most cases, electrification is brought about by a combination of circumstances. If any of the necessary elements are missing, the scheme "falls through." In other words, electrification is, very frequently, incidental to something else!

Since conditions are not always to be had "ready-made," it follows that they must be met as they are. In meeting them, the steam locomotive is still very active and useful, and bids fair to remain so for a long time.

On some roads the steam equipment in suburban service is about worn out, and must be replaced by something better. These replacements are now being made.

For many years the Boston & Albany used old wooden coaches in suburban service and whatever types of engines that were available; many of the latter being of the 4-4-0 type. There were—and are—some engines of the 2-6-6 tank type, some of which were recently modernized, and appear to be well-liked on the short runs.

New steel coaches, specially adapted for suburban service, have been in use for some time and are far superior to the old equipment formerly employed. As a photograph will often give a better idea of things than pages of text, a B & A suburban train is shown herewith. The engine is No. 317 of the 2-6-6 type, and two of the three cars are of the new design.

With regard to schedules: Speeds are not very high because stations are rather close together. On the Highland Branch most of the stations are less than a mile apart! On the main line, between Boston and Framingham, the situation in that respect is much the same, though there are one or two stretches of fair length.

Under these conditions, a train barely has time to "get going" when it is time to "shut off." Of course, this sort of a job is a regular "grind," since the brake-shoes do as much work as the drivers!

Including both directions on the Highland Branch, there are, probably, half a hundred trains, daily except Sunday. In addition, there are several Saturday Only trains.

A similar survey of the main line indicates an even greater number of these short runs. In addition, the local tracks are used by Framingham and Worcester locals.

These facts help to explain why the South Station in Boston is such a busy place!

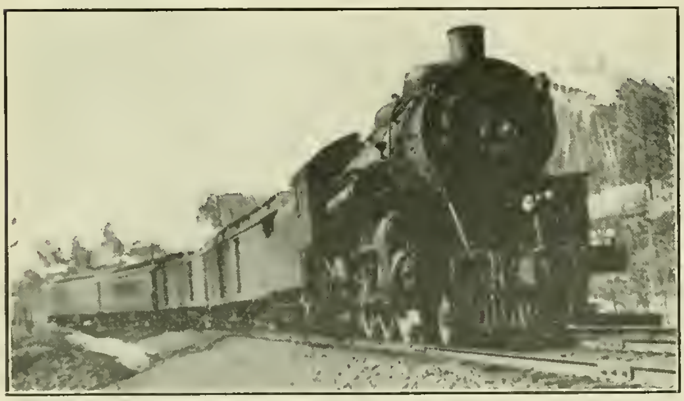
Recent reports that the B. & A. is to have further

L-1-a Type Locomotive of the Boston & Albany at Newton, Mass.

tank engines—this time of the 4-6-6 type—show that the method of handling suburban business is to be the same as heretofore, only more so!

On the Albany Division—i.e., west of Springfield—local passenger trains are handled by Pacific type locomotives of the older classes. Train No. 44 is shown in an accompanying photograph. The engine is No. 538, of Class K-e, and built at the Schenectady Works of the American Locomotive Company in 1908. Cylinders 22x26 inches; drivers 75 inches in diameter; weight, without tender, 238,000 lbs.

I have selected this photograph for a special purpose. It will be observed that the train consists of four cars.



Eastbound Local No. 44 of the Boston & Albany at Huntington, Mass.

No doubt, some readers who see it will make caustic remarks about the use of a Pacific type engine on such a light run; so we might as well answer their criticisms in advance.

The assignment of motive power on any road involves a great deal more than the weight of any one train. For example, an engine may have a light "turn" today because nothing else is available. Tomorrow, the same engine may be called upon to handle a much heavier train. The fluctuations and exigencies of traffic are responsible for this.

Another thing: Engines just out of the shop are "broken in" on light runs. Furthermore, engines due for overhaul finish out their mileage on light jobs. All this is plain, common sense!

Even when a Pacific type engine is regularly assigned to a light run, there is some good reason therefor. Railroad men are not the "chumps" that their critics think they are!

Sometimes, also, an engine has a very heavy "turn" in one direction; to balance which she is given an easier job on the trip "home." What could be fairer?

Try to think of a road's motive power as bearing a load; that load being the aggregate traffic. Correct assignment of the motive power requires an equitable adjustment of this vast load so that engines and crews will not be overworked!

Speaking, specifically, of the Albany Division: It may be doubted that small engines could handle even four cars on the grades which abound there, and with due regard for stops and all other considerations.

It is to be hoped that the foregoing explanations will satisfy the gentlemen who like to indulge in "wise-cracks" about motive power assignment.

Safety Work of the Railroads

The railroad's safety record has improved 48½ per cent in the past fifteen years, as measured by fatal accidents per 100,000 population. This is the conclusion of a summary of accidents just prepared by the Statistical Committee of the National Safety Council. The survey places the railroads in the forefront of the industries which have been accomplishing successful safety work in recent years.

The report shows that in 1911 the fatality rate per 100,000 population, as the result of railroad accidents, was 13. This compares with 6.7 per cent for 1926, a decline of 48.5 per cent.

The number of deaths alone is not an accurate measure of the trend of accidents, because changes in population from time to time are not taken into account. Deaths in a year per 100,000 persons living in that year, is the usual method of making allowance for this factor.

The death rate for all accidents throughout the country was 78.6, a decrease of 7.2 per cent since 1911. All of the decrease, however, occurred prior to 1921. Since then the death rate from accidents has gone steadily upward. This is largely the result of the growing automobile death toll which in 1927 was more than eight times that of 1911. On the fatal railroad accidents last year, 1.4 per cent represented passengers killed; 23.1 per cent represented employes killed; whereas 75.5 per cent represented other persons killed. The report comments on these figures as follows:

"Less than one-fifth as many passengers and only one-half as many employes were killed in 1927 as in 1918; 'but the figure for other persons' is practically the same for the two years. In 1918 'other persons' made up only about 50 per cent of deaths, but in 1927 they were 75 per cent of the total."

These facts on railroad accidents serve to emphasize the importance of the automobile hazard because it is largely the grade-crossing deaths included among "other persons" that have forestalled any reduction in this group. A large number of trespassers—children and adults playing or walking on railroad tracks—are also included in the total of 'other persons' killed." The automobile accident fatality rate increased from 2.2 per cent in 1911 to 17.9 in 1926, an advance of 713.6 per cent.

Reports to the Railway Fuel Association
New Locomotive Economy Devices

The business of railroads being transportation, their right to existence, like any other industry, depends upon how efficiently and economically they can produce the service they have to offer, and to this end the locomotive is really the major factor, as transportation is wholly dependent upon its motive power. The efficiency with which it is handled reflects the railroad's prosperity.

From the beginning, locomotive development has followed the demands of transportation for greater power and increased economies, with the result that today our locomotives have reached their maximum limitations in size and weight, and the problem of the designing engineers has been turned to the perfection of devices for still further increased power and economies, which must be accomplished within these limitations.

Much success has been accomplished in developing and perfecting devices for economizing in the production of steam, but there has been less accomplished toward economizing in the utilization of this power after it has been produced. For this reason the Committee has sought to give more attention this year to those devices that tend to improve the utilization of steam in the locomotive cylinders through improved steam distribution and a more scientific control of the cut-off on which locomotives are operated.

Distribution Valves

Various methods of steam distribution have been arranged and rearranged in attempts to economize in the utilization of steam. Long valve travel settings, with a late maximum cut-off, have been used in view of obtaining increased steam lap and consequently an increased expansion period and steam economy. This process, however, has been rather an unsuccessful procedure because of the small increase that it is possible to obtain in the expansion period.

The basic principles for obtaining pronounced economy in steam consumption can be defined as follows:

FIRST: Reduce the amount of steam taken from the boiler for each piston stroke, to the minimum required to produce the necessary cylinder power by means of a restricted cut-off.

SECOND: By utilizing the fullest possible amount of the energy of this steam by means of the extremely long expansion period which the restricted cut-off permits.

THIRD: By reducing the negative pressure (back pressure) to a minimum by providing adequate exhaust port openings.

In arranging a steam distribution covering these features it is necessary that some means be employed to maintain as reliable starting power as is produced by the conventional late cut-off principle. The attention of this Committee has been called to a new Distribution valve designed to cover these economic features and is provided with an automatic auxiliary admission which insures starting reliability. One of the several means of providing for this auxiliary admission is shown in the accompanying illustration of the Duplex valve.

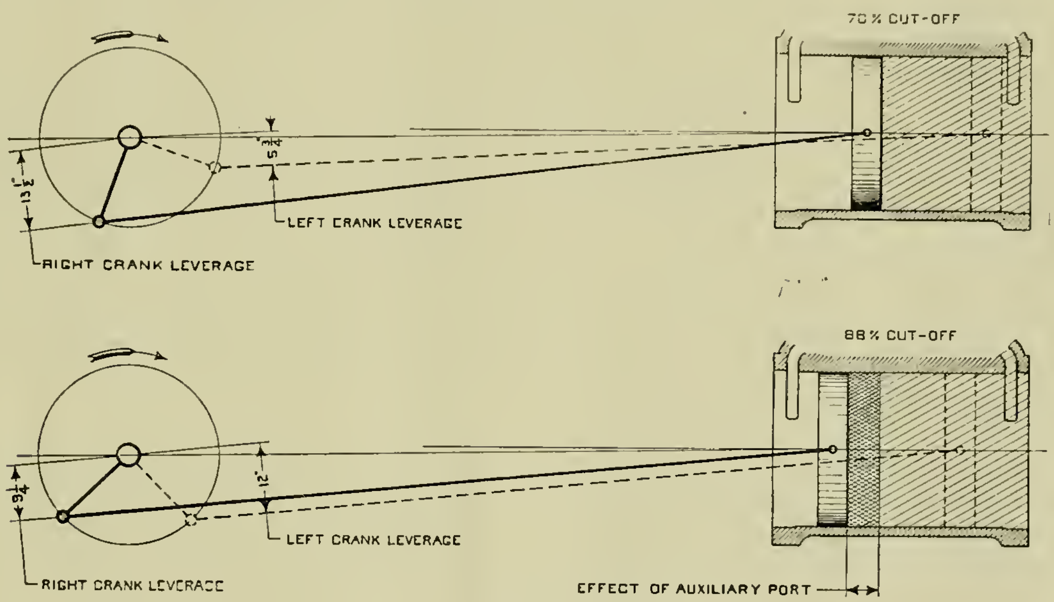


Diagram Showing Effect of Auxiliary Port

Should a locomotive stand in such position that both cylinders will take steam there will be no difficulty in starting, but if one crank is at the position of cut-off, then the opposite cylinder must provide the starting power. The chances of a locomotive standing in such a position that both cylinders will take steam are only 1 in 4 at 70 per cent cut-off, as against 15 in 25 for 88 per cent cut-off. The following diagram clearly shows the effect of the auxiliary admission on the crank leverages which insures starting power.

By referring to the 70 per cent cut-off chart it will be noted that the right crank is at the position of cut-off and therefore all power must be exerted through the left crank, which having a leverage of only 5¾ inches is insufficient to insure reliable starting.

The shaded section of cylinder volume on the 88 per cent cut-off chart clearly shows the additional piston and crank movement that is effected through the auxiliary admission and which has advanced the left crank to such a position that a 12 inch leverage is now available and reliable starting is assured.

The following comparison between the valve events of a Mikado type locomotive with the conventional valve setting and as arranged for the Duplex distribution valve will clearly demonstrate the improvements obtained with this new valve:

CONVENTIONAL VALVE		VALVE SETTING	DUPLEX VALVE	
%	Inches		%	Inches
—	14"	Diameter	—	14"
—	7"	Travel	—	8-1/4"
—	1-1/8"	Steam Lap	—	2"
—	3/16"	Lead	—	3/16"
—	L. & L.	Exhaust	—	1/8" LAP.
		EVENTS FULL GEAR		
87.9%	28.1/8"	Cut-Off—Main Ports	74.2%	23-3/4"
—	—	Cut-Off—Auxiliary Ports	87.5%	28"
96.4%	30-27/32"	Release	93%	29-3/4"
8.5%	2-23/32"	Expansion Period	18.8%	6"
—	1-5/16"	Exhaust Port Opening at End of Stroke	—	2-1/16"
3.6%		Closure	8.3%	2-21/32"
		EVENTS AT 25% CUT-OFF		
—	2-27/32"	Travel	—	4-7/8"
—	—	Increase in Travel Velocity	—	71.4%
25%	8"	Cut-Off	25%	8"
69.2%	22-9/64"	Release	73.7%	23-19/32"
44.2%	14.9/64"	Expansion Period	48.7%	15-19/32"
—	19/64"	Maximum Admission Port	—	7/16"
—	1-15/16"	Exhaust Port at End of Stroke	—	2-1/16"
—	1-27/64"	Maximum Exhaust Port	—	2-5/16"
30.8%	9-55/64"	Closure	30.6%	9-13/16"
1.6%	33/64"	Preadmission	.6%	3/16"

This comparison shows that the full gear valve travel has been increased from 7 inches to 8¼ inches, which gives an increase in the valve velocity at 17.8 per cent. At 25 per cent cut-off the increase in velocity is 71.4 per cent. Increased valve velocity insures improved and more positive valve events, reduced restriction or "wire drawing" of steam, permits more instantaneous admission and exhaust, and greatly aids in the reduction of back pressure. The steam lap has been increased from 1⅛ inches to 2 inches, an increase of 77 per cent. The feature of increased steam lap is to increase the expansion period and exhaust port openings.

It will be noted in the above comparison that in full gear the expansion period is increased from 2 23/32 inches to 6 inches, an increase of 120 per cent, and at 25 per cent cut-off, from 14 9/64 inches to 15 19/32 inches, an increase of 10.2 per cent. This will give an increase in expansion for the average working cut-off in freight service of from 40 per cent to 60 per cent. The increase in the steam lap also provides a 5.2 per cent increase in the exhaust port opening at the end of the stroke and a 25 per cent increase in the maximum exhaust port at 25 per cent cut-off.

This valve has a high velocity at the instant of opening and closing the ports, together with larger port openings, and a longer duration of the maximum port opening. This results in an indicator diagram with steam and expansion lines raised, and exhaust and compression lines lowered. Hence the mean effective pressure is much higher for a given speed and cut-off. Indicator cards taken from a Government light Mikado type locomotive equipped with these valves, operating at various speeds and cut-offs are here shown.

In addition to the fuel economies obtained there has been a very noticeable improvement in running gear maintenance on locomotives equipped with these valves, which is one of results derived from the unusually large exhaust port openings. Locomotives so equipped have almost without exception shown an increase in running speeds of from 6 per cent to 8 per cent with their standard tonnage trains, and their boiler pressure is more easily maintained. The greatest economies have been shown on locomotives handling full rated tonnage trains and in high speed, long run passenger service.

It should be clearly understood by engineers that locomotives equipped with Duplex distribution valves are operating on a restricted cut-off when the Reverse Lever is "in the corner" and that, unlike the conventional type, they should not be "hooked-up" until the train has accelerated to twelve or fifteen miles per hour.

The most satisfactory results are obtained where the reverse lever is manipulated in conjunction with a back pressure gauge, in which case the correct operating back pressure will be found to vary with different service conditions. Ordinarily the best results are obtained with back pressure ranging from 5 to 8 lbs. However, on roads where the coal conditions require a reduction in the exhaust nozzle tip the back pressure may run as high as 10 to 12 lbs.

Even though Duplex distribution valves operate with an increased valve travel, it has not been found more difficult to lubricate, and in most classes of service a decided improvement has been shown. These valves are adaptable to all classes of service and will produce desirable economies with the present steam pressure on existing locomotives. Where increased steam pressure or increased cylinder diameter is obtainable on existing locomotives or on new locomotives where these features may be provided for, even greater economies should result.

Mechanical Cut-off Control

During the past year the mechanical cut-off control has been improved by the addition of a converter valve designed so that a more accurate registration of back pressure can be obtained. This device is a development of a sylphon, having one side connected to the exhaust cavities of the cylinder and the other side of equal area being an air chamber supplied with air from the reducing valve line on the locomotive.

The sylphon is held in balance by the admission of air through the slide valve shown in the accompanying illustration. An increase of pressure in the exhaust cavities of the locomotive causes the sylphon to move the slide valve opening the port and admitting air into the air chamber until the pressure balances the steam side of the sylphon, closing the valve. Similarly, the reduction of back pressure causes movement of the sylphon in the opposite direction, opening the exhaust port until the pressure in the air chamber equals that in the steam chamber, at which time the port is closed.

The back pressure line to the automatic cut-off controller and cab gauge is taken from the air chamber of the sylphon. This pressure is at all times identical with the steam pressure in exhaust passages of the cylinder. This gives the advantage of being able to have a large pipe carrying the exhaust pressure from the cylinder while a small pipe may be used from this device to the controller and gauge. By using air pressure for recording the back pressure, the present trouble of frozen back pressure lines is eliminated and also it is possible to apply this line on the outside of the jacket as is done with other air lines. A few other features in connection with the functions of the converter valve are as follows:

A. Changes in exhaust pressure are transmitted to the pressure responsive devices more quickly, practically instantaneously.

B. Pulsations are eliminated.

C. The presence of a hydrostatic head as it influences the accuracy of gauge indication is eliminated.

In explanation of this; for example, the difference between the elevation of the cylinders and the gauge in the cab is 6 ft. Conveying exhaust steam back into the gauge in the cab causes exhaust steam to condense and there is actually water in the pipe. Water is practically always present back at the gauge or the gauge would not function properly. This water imposes a hydrostatic head on the pressure at the cylinders: In this instance the hydrostatic head of 6 ft. is equivalent to 3 lbs. pressure; therefore, with 10 lbs. at the cylinder, there would be only 7 lbs. at the gauge. As the pressure at the cylinder is constantly changing, the relative effect of the hydrostatic head is constantly changing and there is, therefore, inaccurate reading of the gauge as to the back pressure existing at the cylinder.

D. Conveying back pressure steam back to the gauge in the cab has a deteriorating effect on the tube of the gauge, particularly where the boiler compounds are used containing mercury. This is because the wall of the tube is so very thin, which is necessary to have a sensitive gauge.

E. Conveying back pressure steam back to the cab causes the back pressure line to be filled with carbon, causing the line to plug up, either giving an incorrect reading in back pressure, a lag in these readings, or the line to become plugged entirely.

Locomotive Valve Pilot

A general analysis of the tests of a device known as the Loco Valve Pilot recently conducted on the New York Central R. R., is reported to the Committee as follows, the device being applied to a Mikado type, Class H-5f locomotive, Road No. 3785, for nine test runs without assistance of device and eight runs with the device. The device was first applied before any tests were run, but was covered up so that the engineers did not know that a recording tape was keeping a record of the speed and cut-off.

An approximate saving of 8 per cent was effected in coal per 1000 gross adjusted ton-miles per train hour by use of the valve pilot. Conversely, on the basis of equal coal consumption with and without the use of the Pilot, an increase of 14 per cent in 1000 gross adjusted ton-miles per train hour was effected by the use of the Pilot. The difference in values of saving is due to the accumulative effect of reduction in coal rate.

The indications are that with the use of the Pilot, trains of 3,000 to 3,300 actual gross tons may negotiate the ruling grade located at Haverstraw, in eastbound runs, without the assistance of a pusher which is now used. Considering the time element for train operation, it was found that when indication was followed for selection of cut-off to give maximum drawbar pull, there was a reduction of 7 per cent in train time based on minimum train time in series without use of Pilot. In general, within the range of tonnage carried during the tests, use of the Pilot reveals a definite economy of operation which, within reasonable limits, seems to be somewhat increased with heavier tonnage.

In analyzing the results of these tests, two important factors should be considered:

First—the personal element introduced by the performance of each engineman. Two of the enginemen who operated the locomotive during tests were commonly known as "heavy runners," that is, they were ordinarily in the habit of operating with a rather heavy or long cut-off, but the use of a back pressure gauge (during all tests, without and with Pilot), undoubtedly resulted in a smaller margin in favor of Pilot than would have been produced in ordinary performance on this Division.

Second—during the first series of tests (without the Pilot), the average temperature was 10° F. higher than the average temperature of second series (with the Pilot). This not only reduced the available drawbar pull, but also increased the journal friction in the train. Since available data in the matter of compensating for low temperature vary so widely as to be hardly applicable, no attempt has been made to show the effect of cold weather in the results of the test, but is mentioned here to suggest due consideration.

The following table presents the more important data and results obtained from the tests:

Test No.	Gross Adj. Tons	Gross Adj. Ton-Miles	Train Time Hours	Total Coal Fired—Lbs.	Coal Per 1000 Gross Adj. Ton-Miles Per Train Hr.-Lbs.	Average Cut-Off in Percent	Atmospheric Temperature Deg. F.
			WITHOUT PILOT				
1	3376	383677	5.0	21100	280 06	55.5	62.5
2	2080	271479	5.2	16900	323.71	55.5	47
3	3276	361952	5.35	19900	293.18		34
4	2538	331235	5.93	18500	331.20	51.5	26
7	2512	331531	5.65	16400	279.49	50.	44
8	1800	234900	5.98	14600	371.68	50.75	42
9	3123	375039	5.3	21200	307.73	48.5	45
11	2910	302231	5.16	18800	332.6	49.	51
12	2244	292842	5.23	16600	296.47	52.8	55
Aver.	2651	321209	5.42	18222	312.9	52.5	45.28
			WITH PILOT				
51	3150	364714	4.61	22600	288.83	51.5	41
52	2455	320404	5.1	16900	269.04	47.3	34
53	3178	373268	4.98	19400	269.97	45.8	35
54	2606	340115	5.05	18200	270.23	50.8	22
55	2549	274083	5.61	16400	343.97	41.9	37
56	2889	377015	6.28	14500	241.53	45.	42
57	2803	283995	5.16	16400	303.92	40.5	51
58	2318	302525	5.58	16900	311.72	41.8	22
Aver.	2743	329514	5.25	17666	287.4	45.7	35.5

The Loco Valve Pilot consists of two major parts, speed indicator and recorder and cut-off position indicator and recorder.

The speed element is the centrifugal type located in the instrument box. It is driven by means of flexible chain from friction wheel in contact with the periphery of the driving tire. The cut-off indicating element consists of a hand revolving on the same axis with the speed hand and a recording pencil for tape record, operated in the same manner as that for the speed element by means of a rack. The position of the cut-off hand and pencil is controlled by means of a steel cable under constant tension, actuated by a cam roll which in turn is moved by a cam, the motion of the latter being controlled by a rack and gear from the connecting rod connected to the bell crank attached to the tumbler shaft.

Any change in the cut-off position as made with the reverse gear will change the position of the cam, which is indicated by a proportional change in the position of the cut-off hand on the dial of the instrument. The cut-off required to give maximum drawbar pull for various speeds is obtained from the drawbar—pull speed curve of the engine. It will be noted, as an example, that at 10 miles per hour the maximum drawbar pull is 41,000 lbs. and the dynamometer tests from which this curve was obtained, show that this pull at 10 MPH is obtained at 87.5 per cent cut-off, all of which facts are indicated by the white band. The red band indicates the speed at which the engine is traveling, that is, when it points to 10, the engine is traveling 10 miles per hour.

Suppose an engineer going over the road gets the two hands together, and then finds he is working the engine harder than he needs. He then "hooks up" the locomotive with the white hand advancing and leaving the red hand till the operating speed is satisfactory. If the speed should fall below the desired valve, he drops the reverse gear a little until the speed returns to that desired.

The maximum economy of operation is obtained when the white hand is as far in advance of the red hand as operating conditions will warrant.

In operation, then, both the speed hand (red) and the cut-off hand (white) are kept together when maximum drawbar pull is desired. The reverse lever is operated so that the white hand moves to a position as far in advance of the red hand as is possible while maintaining such speed as operating conditions demand. The use of shorter average cut-off will result in reduced steam admission to the cylinders and decreased fuel consumption.

Feed Water Heaters

The total number of locomotive feed water heaters installed on all railroads in America each year since 1920, and those on order up to May 1st, 1928, are as follows:

	Pump Type	Injector Type
1920	7	—
1921	54	—
1922	234	—
1923	1429	—
1924	2123	24
1925	2551	37
1926	3527	362
1927	4918	519

Feed water heaters of either the pump type or injector type are considered as standard equipment on nearly all new locomotives purchased and many roads have a program of application of feed water heaters to their important road power not so equipped at the time of purchase. There has been no development during the past year in feed water heating that involves new principles. Last year a new closed type of feed water heater was reported for which a centrifugal pump was used. Tests made with the use of this feed water heater indicate savings comparable with that of feed water heaters of other types, while the service rendered is satisfactorily performed.

During the year a new type of centrifugal pump was placed on the market by The Superheater Co. for use with their closed type heater. A report was made in 1925 on a duplex pump developed by this company which was designed to give a constant flow of water so that the boiler check would open and remain open during the time that the pump was operated, the same as an injector. A centrifugal pump, of course, delivers a constant steady flow of water, but has several advantages over piston type of pump, such as occupying less space, as it is greatly reduced in size and weight, has only one moving unit, so that wearing parts are reduced, pounding eliminated, and it is claimed failure and maintenance are reduced to a minimum, although this type of equipment has not been in service a sufficient length of time to substantiate these claims.

This new pump may be described as a vertical steam turbine driven two stage centrifugal pump. The turbine is double acting, steam first flows through a primary nozzle, then the buckets in the turbine wheel from there it passes through the secondary nozzle and then through the buckets of the turbine wheel a second time. The exhaust steam passes into the feed water heater. Water flows to the first stage impeller and is delivered to the second stage impeller at approximately one-half the final delivery pressure. The second stage impeller raises the water to the necessary pressure required to deliver it to the feed water heater.

The amount of water discharged by the pump is determined by speed which is controlled by the steam pressure at the nozzle, therefore the volume of water required to supply the boiler is controlled by the steam valve located in the cab. An automatic control is provided which will prevent the pump from starting or will stop it so that no damage will result from over-speed in case there is no water supply available for pumping, or in case the pump runs out of water.

Exhaust Steam Injector

No new developments have been made in the exhaust steam injector, but there has been a constant increase in their use. Some of the previous troubles have been overcome by change in design and improved service is being obtained by experience of the operators and by better supervision.

Locomotive Steam Desaturators

Since our last report there has been very little progress made in the use of steam desaturators. We find that on one road operating through a bad water district, tests have been conducted on the Centrifix unit referred to in the 1927 report, and results obtained would indicate that there is a field for this device.

The installation is quite similar to that covered in our last report, but the units have been redesigned as shown in the cut. There was some question as to the disposal of the water thrown off from the unit, and this has been taken care of in the new design by having a race at the top and bottom of the unit, discharging the water below the water line of the boiler. Test conducted showed that this device functioned and that the water was satisfactorily delivered below the water line in the boiler.

Calorimeter tests showed that the quality of the steam was increased from 96.0 without the Centrifix to a maximum of 98.90 with the Centrifix. There are no figures available showing an increase in superheat, as figures are not available showing the superheat on this engine prior to applying the Centrifix. However, on other engines of a similar class the superheat temperature has been secured and the Centrifix equipped engine runs 15° to 20° higher superheat.

The Centrifix separated from steam at the throttle and returned to the boiler from 486 to 1156 pounds of water at boiler temperature per hour of service. From this it has been computed that on a monthly engine mileage of 3,000 miles, the saving in coal would average about 8,000 pounds per month. Coincident with this saving is the renewal of both soluble and insoluble salts, suspended matter, etc., from the steam which furnishes an added protection to superheater, valves and cylinders.

The performance of this Centrifix and other desaturators will be followed further and subsequent reports of the Committee will carry additional information in regard to same.

Direct Steaming

As a phase of locomotive feed water heating, this Committee has previously reported on the reclamation of heat from steam and hot water in locomotives arriving at terminals, and in our last year's report attention was given to this method in connection with the Direct Steaming of locomotives at terminals without fire on the grates, the steam for this purpose being generated in modern stationary boilers operating at an efficient rate and in some instances utilizing a grade of coal that can be purchased at a considerably lower cost than locomotive fuel.

During the year elapsed since the presentation of our previous report five locomotive terminals have been equipped thruout for the Direct Steaming System above referred to. Three of these installations are in new engine houses as follows:

Gouldsboro terminal operated by the Missouri Pacific Lines at New Orleans.

Riverside terminal of the Big Four Railroad at Cincinnati.

Fort Worth terminal of the Texas & Pacific Railroad.

In addition to these installations of the Direct Steaming System at new terminals during the past year the Grand Trunk Western Railroad has equipped its Elsdon engine house in Chicago and the Chicago and Northwestern has recently completed an installation of seventy-two Direct Steaming Stations at its Chicago Avenue and Halsted Street terminal.

The principle involved in each of these installations of the Direct Steaming System is the same as described in previous reports of this Committee, but at the two Chicago terminals and the Riverside engine house in Cincinnati, the chief object of this System is to eliminate all smoke from locomotives standing in the engine house or on outside parking tracks.

This feature has also been taken advantage of at other locomotive terminals where the Direct Steaming System has been installed and this Committee is advised that there has never been a locomotive fire lighted in the Gouldsboro engine house since July, 1927, when this new terminal was first placed in service. At both the Gouldsboro and Fort Worth terminals, however, the primary purpose of installing this System was to save fuel and reduce the time required for handling locomotives thru the terminal.

At the Gouldsboro terminal the time required to fill and steam locomotive boilers to 100 pounds pressure without a fire in the locomotive has been reduced to one-half hour. At the new Ft. Worth terminal of the Texas & Pacific, about 70 locomotives are now being turned daily without fires in the engine house. The majority of these locomotives are of the Texas Type (2-10-4) with a boiler capacity of approximately 5000 gallons. The time required to steam these engines to 150 lbs. pressure without a fire in the locomotive is about 45 minutes, including the time required to fill the boiler.

The Chairman of this Committee is indebted to Mr. A. P. Prendergast, Superintendent Motive Power, Texas & Pacific Railway, for the following letter in regard to performance of the Direct Steaming System:

"We have just opened our new shops and enginehouse at Ft. Worth, Texas, the engine house and power plant facilities being provided with the Direct Steaming and hot water washing and filling equipment, and we are now handling our engines at that point under the Direct Steaming methods and obtaining efficient and economical results that fully measure up to our expectations together with the claims and representations made by the manufacturers of the Direct Steaming System. Later on we will have some very interesting figures as a result of our regular enginehouse performance and would be glad to furnish you with any data you may later on desire and call on us for."

On the Grand Trunk Western Railroad with which the Chairman of your Committee is connected, results from operation of the Direct Steaming System at the Battle Creek and Chicago terminals during the past year have confirmed the results of steam consumption tests given in our previous report. At the Battle Creek terminal where a part of the engine house was equipped for Direct Steaming locomotives several years ago, a careful check has been made over a period of several months to determine the average fuel saving resulting from the operation of this system.

This fuel saving has amounted to about 800 pounds of coal per locomotive turned in the Direct Steaming section of the engine house compared with locomotives handled in the usual manner in other sections of the engine house. This is a net saving which takes into consideration the stationary boiler plant coal consumption to supply stack blowers for locomotives fired in the usual manner and also the stationary boiler plant coal required to generate Direct Steam supplied to all locomotives steamed by this System.

The Elsdon engine house, which is located at 49th Street and Kedzie Avenue, Chicago, was equipped last Fall for Direct Steaming all locomotives turned at this terminal, and has operated continuously with this system since its installation. Two new water tube boilers of 300 H. P. capacity each were installed to supply Direct Steam to locomotives at this terminal. These boilers have chain grate stokers and an induced draft fan system in the stack breeching which enables them to deliver considerably over their normal rating and the entire steam requirements at this terminal, including the Direct Steaming load, can be carried on one boiler.

In this connection it should be noted that practically no steam is supplied for heating the engine house, as the heat radiated from locomotives connected to the Direct Steam supply main is sufficient to maintain a comfortable temperature in severe weather. This in itself effects some fuel saving, but the principal fuel economy lies in the use of a lower priced coal in the stationary boiler plant than required for locomotive use and the greater efficiency of these stationary boilers operating at their most efficient rate. The result of a fuel test at this terminal as described in a recent issue of the *Railway Age* may be summarized as follows:

It requires an average of approximately 112 lbs. of coal per hour to hold a large locomotive in the engine house at a boiler pressure of 150 lbs. with Direct Steaming, while the quantity of coal burned on the grates in order to hold a locomotive at this pressure by the old method averaged 345 lbs. per hour. These figures are taken from recent tests of the power plant and engine house operation, but in actual service the average steam pressure maintained on locomotives are much lower so that the overall fuel saving as reflected in the aggregate coal dock issues to locomotives is about 30 per cent of the above figures, or about 70 lbs. coal for each hour that a locomotive is held at the terminal. With an average layover of 9 hours this fuel saving amounts to approximately 630 lbs. coal per locomotive turned. But the further advantage of keeping engines hot, enabling roundhouse employees to make tests at any time, diminished wear on buildings due to soot and gas and elimination of steam for heating the roundhouse cannot even be estimated at this time. It is safe to say, however, it will be even greater than the fuel saving.

Locomotive Design to Reduce Maintenance

By W. E. WOODARD, Vice-president, Lima Locomotive Works, Inc.

It seems fair to assume that the new power purchased and new locomotive specifications prepared during the past two years indicate the trend of locomotive construction, even though the amount of new power represented is relatively small. Judged by this standard, there is not the slightest question about the railways endorsing the principles of low combustion rates, higher boiler pressure, limited cut-off, and booster.

To this association is due much of the credit for the magnificent showing in fuel economy made by the railroads in the last few years. How much more it is possible to accomplish may be realized from this fact: The locomotives possessing all of the features just enumerated represent less than five per cent of the freight power of the country. There are, therefore, plenty of opportunities yet open to reduce the total coal bill of the railroads by the purchase of modern power units.

Advances are almost always initiated as the result of comparisons. One result of the splendid reduction in total locomotive fuel consumption already made is that by comparison attention is forcibly called to another large item of operating expense which has now actually become greater than fuel costs; that is, locomotive maintenance. Although maintenance has been reduced, it has not fallen as rapidly as fuel costs, and now locomotive maintenance is really taking a greater proportion of operating expenses than is coal.

And thus it appears reasonable that the locomotive designer in planning future developments should consider changes in mechanical construction of the locomotive which promise substantial improvements in the maintenance item. And these should be undertaken and go hand in hand with any further advances directed to betterment in fuel performance.

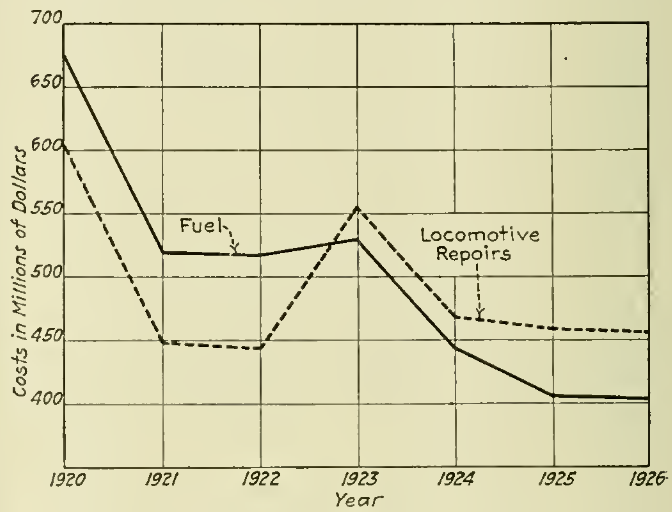
I do not want to imply that locomotive designers have ignored the maintenance problem. But I think it is a fair statement to say that fuel economy and increased power have received the major effort and that no change in fundamental design has recently been made which is especially directed toward reducing locomotive maintenance. In my opinion, one of the most important possibilities in future locomotive design lies in this direction, particularly as greater reliability and longer life of the machinery directly aid in the long-run program and more intensive utilization of power, which in turn will result in greater fuel economy.

There are naturally two major divisions in locomotive maintenance: The maintenance of the steam generating plant and the maintenance of the steam-using plant. The division of the cost of maintenance between these two general items appears to be roughly about one-third boiler and two-thirds machinery.

The solution of the boiler problem probably lies in some form of water-tube firebox, which will eliminate staybolts and upon this problem much work is being done, although as yet there are comparatively few such boilers in service.

Improvements in the machinery portion offer possibilities which can be used at once. Moreover, machinery improvements offer the greatest chance for reducing maintenance costs by attacking the major portion of this expense. These improvements can be made without going to any untried elements of construction. The various designs which I will show have been developed for the purpose of reducing machinery maintenance, and they not only offer possibilities in this direction, but also provide means within our present width limits for increases in power and size beyond the range possible with present construction.

In the design of the machinery of a locomotive two fundamental dimensions receive, or at least should receive, major consideration. The two dimensions (commonly called frame centers and cylinder centers), together with the piston thrust or load which is set by the side of cylinder and steam pressure, determine the major stresses which come upon the machinery portion of the locomotive.



The Trend of the Cost of Locomotive Fuel and Repairs on Class 1 Railways

As locomotives have increased in size and power, the distance between frame centers has steadily decreased while cylinder centers have, on the other hand, spread out, resulting in greatly increased leverage or bending moment about the frames. As a result, bending moments on frames, axles, and pins, as well as bearing pressures on all journals, have increased in magnitude until now they are many times those existing on locomotives built only a few years ago. No presentation of figures is needed to prove this point. Anyone who rides locomotives of great power has felt the working of these enormous forces upon the locomotive structure.

The suggestions I present attack this fundamental problem by offering a way to decrease these stresses materially by reducing the distance between cylinder centers. They also provide a more substantial connection between the cylinders and the main frames, as well as a rigid unitary support for the guides and valve motion. All three of these elements of design are vital to the maintenance problem.

The drawing of the tandem main rod drive shows the steps by which the new designs were evolved. The guides are moved slightly ahead of their ordinary position, so as entirely to clear the pin and rod on number one driving wheel, thus allowing the cross-centers of the guides and cylinders to be pulled inwardly. The main rod is connected to the second driving wheel and, on account of using the tandem main rod drive, the force required to turn back drivers is transmitted directly to them without going through the main pin, as is the case with the ordinary arrangement. This leaves the main pin with only one driver to turn, thus making it possible to cut down the length of this bearing. This new arrangement makes possible the building of the heaviest type of locomotive with only 88-in. cylinder centers, a decrease of 5 in. to 7 in. over recent large locomotives. This means a reduction of the bending moment on the frames, axles, and pins of as much as one-sixth, which is a significant decrease in view of the magnitude of these forces.

The drawing of the tandem main rod drive shows the effect of the arrangement in the overall width of the cylinders. The relief afforded in this one item alone is at once apparent to the mechanical officers who have for years been trying to squeeze their locomotives inside hard and fast width limits.

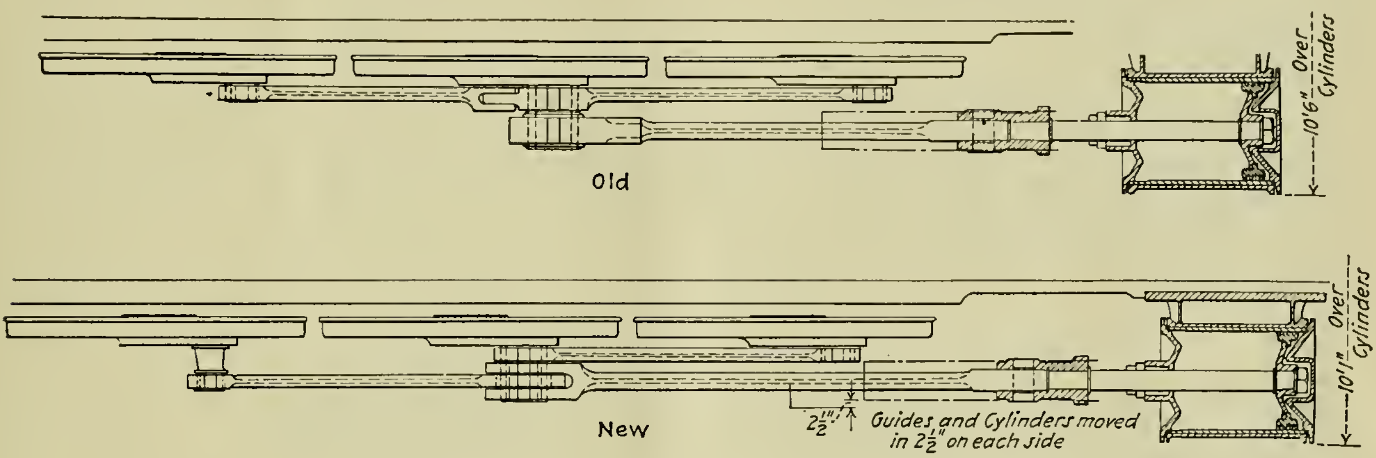
Another advantage which follows is the possibility of using standard cross-cylinder centers for all sizes, thus securing a far greater interchangeability of parts than is between the unitary machinery support and the main frames.

While the 4-8-4 type locomotive, cylinder centers of 94 in. or 95 in. are required with the ordinary construction, with an arrangement of this type, cylinder centers of 88 in. can be secured, thus reducing this dimension by 6 in. or 7 in. The same kind of support for guides and valve motion is afforded as before described for the 4-6-4 design.

In any of the designs, the cylinders may be cast integral. Such an arrangement is illustrated in a drawing which also shows in a little more detail the integral valve motion support and guide supports, as well as the connection between the unitary machinery support casting and the main frames.

The use of this principle is not confined to locomotives having a four-wheel leading truck. A very satisfactory application has been worked out for a two-wheel leading-truck locomotive and this is shown applied to a locomotive having six pairs of coupled drivers, although it is equally applicable to engines having a lesser number of driving wheels.

It would be entirely impracticable to build such a locomotive as this with ordinary design of cylinders, rods, pins, and axles, as cylinder centers would have to be placed 96 in. or 98 in. apart, with a corresponding heavy bending moment on the main axles, crank pins, and other parts. The cylinder centers on the design shown are 88 in., a decrease of 10 in. from the distance required with the ordinary form of construction were it physically possible to apply it.



Tandem Main Rod Drive Compared With the Conventional Type

possible when cylinder centers change with different design.

Still another very important point in this arrangement is the manner in which it lends itself to a construction involving a unitary engine machinery support. This single casting incorporates the cylinder saddles, bumper bracket, deck casting, and front frame filling, together with integral valve gear and guide supports. It provides an unusually fine bolting connection to the main frames ahead of the first driver and is also bolted to the smokebox at the saddle in the usual way.

One of the drawings of the unitary machinery support shows the application of these principles to a 4-6-4 type locomotive. It clearly shows how the arrangement provides for a rigid integral support for the guides and the valve motion. It hardly needs any discussion in detail to show the desirability of a solid support for the guides which will insure against any bending or distortion. While the design shows a single-bar type of guide, such, for example, as used on the Pennsylvania's heavy power, there is ample space in the design to provide an equally rigid support for the ordinary alligator type of crosshead and guide. In the application to this class of power a reduction in cylinder centers of about 5 in. or 6 in. will be secured, bending movements reduced about one-sixth, and the main boxes relieved of more than one-half their usual work. Please note also the very fine connection

The design is in the range of locomotive sizes where the Mallet has been the only unit which the designer could offer. The new design, therefore, shows the possibilities in a field of motive power where maintenance costs have always been high and where a design which promises a reduction in this item of expense is well worth consideration.

The six-wheel trailing truck is shown in the design for the reason that it is necessary to have a firebox of very large size to produce steam economically for the large cylinder. In the design presented a firebox with 151 sq. ft. of grate area is contemplated. There will be nothing revolutionary or troublesome in a six-wheel articulated truck, as the practicability and safety of four-wheel truck designs have been proved by their use on about 200 locomotives operating in a wide range of service.

The possibilities of this design can best be understood by a comparison with a typical heavy simple Mallet of about equal driving wheel weight, shown in the table.

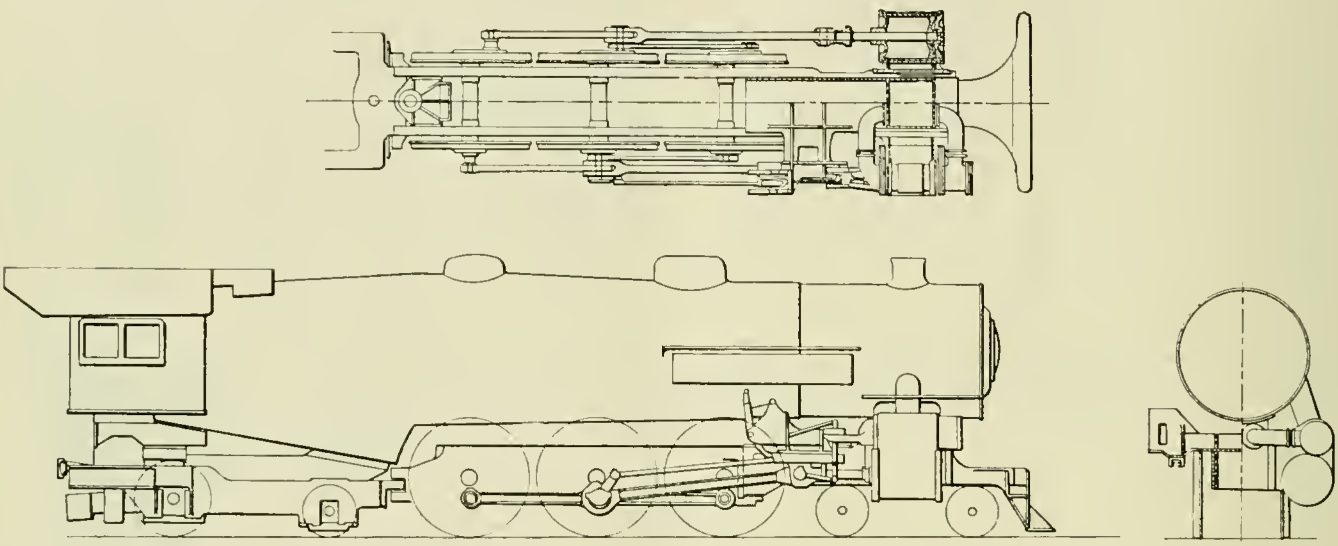
COMPARISON OF A 2-12-6 AND A 2-8-8-2 SIMPLE MALLET LOCOMOTIVE

	2 12-6	2-8-8-2
Tractive force, total	130,000 lb.	130,000 lb.
Cylinders	2—32 in. by 32 in.	4—28 in. by 32 in.
Driving wheel diameter	63 in.	63 in.
Total weight of locomotive	600,000 lb.	600,000 lb.
Boiler capacity, lb. steam per hour	99,600 lb.	80,000 lb.
Increase in boiler capacity, per cent	24½	....

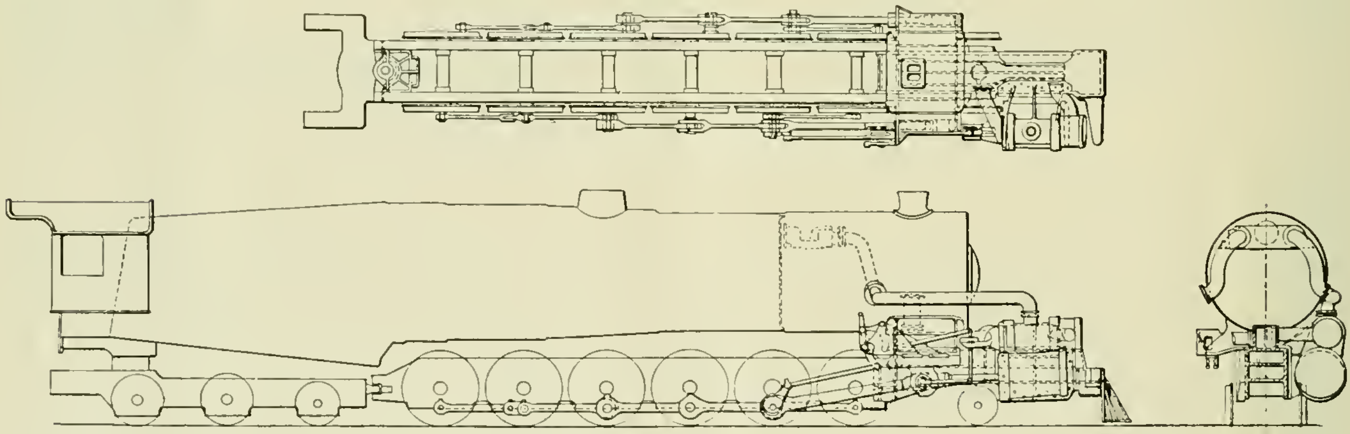
Although the two engines each weigh approximately 600,000 lbs., the 2-12-6 design has a 24½ per cent increase in boiler capacity, which is readily accounted for by the omission of one pair of cylinders, guides, rods, etc., and

There would be a substantial decrease in the maintenance of the driving boxes, rod bearings, and other parts over engines constructed with the conventional cylinder arrangement and rods. This statement can be made with certainty, for the reason that there are now available comparisons between tandem main rod drives and the ordinary rod drives operating under similar conditions and with the same cylinder cross-centers. These comparisons show a decided improvement with the tandem main rod construction in maintenance of both the rods and the driving boxes.

It is evident that a very much more substantial connec-



Unitary Machinery Support as Applied to a 4-6-4 Type Locomotive



A Single Driving Unit Design With Tandem Main Rod Drive With an Adaptation of the Unitary Support for Two-Wheel Engine Trucks

two pairs of driving wheels. The real measure of usefulness of the locomotive is boiler capacity; it is the factor which determines what the gross ton-mile output will be. As far as the construction details are concerned, the bending moments in the 2-12-6 are actually within the limits of several existing locomotive designs and, while some of the features may appear to contain innovations, as a matter of fact there is nothing in the elements of this design which have not a sound basis either in development already done or by comparison with existing practice.

Now, what improvements could be expected if these suggestions were incorporated in a locomotive?

It is at once apparent that a material decrease in width over the cylinders would be secured. Or, within a given width limit, a considerably more powerful locomotive can be built.

tion between the cylinders and the frames can be secured, as there is a much larger space available for bolting.

Based upon the experience with existing tandem main rod drives, mentioned above, it can be predicted with certainty that the racking of the frames and frame connections would be much reduced.

Counterbalance conditions would be much improved, on account of the decreased offset between the planes of movement of reciprocating parts and the balance blocks.

There would appear to be little argument that supporting the guides and valve motion on an integral casting, which is either cast together with the cylinder barrels or directly connected to them, would result in a marked improvement in the upkeep of the guides and valve motion. Moreover, there is ample space to make this casting very rigid, thus insuring the permanent alinement of these parts relative to each other and to the cylinders.

While these suggestions apply particularly to locomotives of great power, the principles are useful in any designs and sizes. The various points have been presented in outline only. But if you will take the designs shown and analyze them you will find that each step has a firm foundation in existing practice and what may appear somewhat novel is only the logical development of things already tried and proved.

The designs offer, I hope, some help in a problem of great magnitude. From the interest displayed by the few railroad mechanical men with whom I have had an opportunity to discuss these features of design, I venture the prediction that soon we will see locomotives in service embodying these improvements.

Baldwin Locomotive Works at Eddystone, Pa.

On Thursday morning, June 28, at 11 o'clock, Daylight Saving Time, several thousand executives and officials of nearly all the American railways and representatives of the leading railway systems of Canada, Mexico, Chile, Cuba and several European countries, together with representatives of National Government, headed by the Honorable James J. Davis; Members of Congress, Army and Navy officials; the Governors and leading officials of Pennsylvania, New Jersey and Delaware; the Mayors and officials of Philadelphia, New York, Chester, Wilmington and other cities; members of the Philadelphia Chamber of Commerce, leading manufacturing and business officials of Philadelphia and Eastern Pennsylvania, and representatives of the country's leading financial institutions, will participate in the ceremonies at Eddystone marking the complete transfer of the business departments of The Baldwin Locomotive Works from Philadelphia to the recently built Administration Building located in the heart of the 600-acre plant at Eddystone.

On the morning of June 28, special trains will leave Atlantic City over the Pennsylvania Railroad for Eddystone, bearing the delegates who will have attended the four Conventions of the American Railway Association which this month meets in Atlantic City. These delegates will be accompanied by their wives. On that morning, a special train will leave 33rd Street Station, New York City, bearing the invited guests from New York, and special trains will leave Broad Street Station carrying the Philadelphia guests.

At Eddystone, the new Administration Building of the Works is within a few hundred feet of Baldwin Station. A huge Grand Stand, seating close upon five thousand guests is now being erected on the broad plaza directly in front of the main entrance to the new eight-story Administration Building. In the center of this plaza there will be erected a replica of the bronze statue of Matthias W. Baldwin, the Founder which now stands on the north plaza of the City Hall, Philadelphia.

The Committee in charge of the transfer ceremonies is composed of Mr. Samuel M. Vauclain, President of the Works, the Board of Directors of The Baldwin Locomotive Works, and the Company's officers.

Promptly at 11 o'clock, the introductory remarks will be made by President Vauclain, who will present as the principal speaker for the occasion Secretary of Labor Davis, and also the Hon. Albert Dutton MacDade, Judge of the Delaware County Courts. Following the ceremonies, the invited guests will be shown through the new building, and also taken on inspection tours of the extensive plant.

The Administration Building, which is one of the most unique, and at the same time one of the most complete office buildings of its kind built in the United States, is in the form of a Greek Cross, affording daylight in every part of the building. It is eight stories in height from the top floor of which a magnificent view of all that part of Delaware County is to be had, together with a magnificent view of western New Jersey and the Delaware River.

The building will house all the operating departments of the Works, including the Domestic and Foreign Sales Departments, the Purchasing Department, and the Works Accounting and Business staffs. On the top floor will be office rooms for Mr. Vauclain and the Vice Presidents and Directors.

While all the operating departments of The Baldwin Locomotive Works will be transferred to the new building at Eddystone, the Works will forever remain a Philadelphia Institution, as it has been for the past ninety-seven years. Matthias W. Baldwin's first Philadelphia Shop where he built "Old Ironsides" in 1832, for the Germantown and Norristown Railroad Company, was located on Minor Street, below Sixth. Within two years, his business of building locomotives grew to such an extent that he selected the location of Broad and Hamilton Streets, the site of the present Philadelphia Works, where a three-story L-shaped building was erected. From that time on until the present, the Works remained in the neighborhood of Broad and Spring Garden Streets, covering an area of nearly twenty acres.

To continue The Baldwin Locomotive Works as a distinctly Philadelphia institution, as it is known in every part of the world, the principal executive offices will be maintained at Broad and Walnut Streets, in the new Philadelphia-Fidelity Building. In the Philadelphia headquarters will be the offices of President Vauclain, the Vice Presidents and the Directors Conference and Board Rooms.

A Comparison of Rail and Truck Hauling

In order to determine what proportion of the total tonnage of commodities moving between cities is hauled by motor truck, and also to develop the factors influencing the choice of motor truck or railroad, a study has been made of the net tonnage transported between Columbus and 30 other Ohio cities by motor truck and rail lines. The survey was conducted by the United States Bureau of Public Roads and the Ohio Department of Highways.

The cities selected are located from seven to 134 highway miles from Columbus, and were chosen to permit an analysis of the effect of length of haul upon the proportion of tonnage transferred by motor truck and railroad respectively. Other cities were selected to determine the effect of indirect rail connections on motor-truck transportation, while others were chosen to ascertain the amount of tonnage hauled by truck between points having no railroad facilities.

The basis for the comparison was the data covering motor-truck net tonnage, and railroad carload and less-than-carload-lot tonnage for an average month of the year 1925.

Although other factors besides length of haul influenced the proportions of total tonnage hauled by motor truck and rail lines respectively, there is clearly indicated the tendency for the proposition of motor-truck tonnage to decrease with increase in distance.

For hauls of less than 20 miles, the analysis shows that 84½ per cent of the total tonnage was transported by motor truck. Between 20 and 39 miles, motor-truck tonnage was 54.7 per cent of total tonnage; from 40 to 59 miles, the motor trucks handled 32 per cent of the tonnage; from 60 to 99 miles, the truck hauled 24.2 per cent of the total, while over 100 miles, the motor truck handled only 2.3 per cent of the tonnage.

The survey also shows that as the percentage of motor-truck tonnage decreases with increase in the length of the haul, both rail carload and less-than-carload-lot tonnage increases.

No appreciable amount of rail less-than-carload-lot tonnage is noted under 40 miles. In hauls which amount from 40 to 59 miles, the less-than-carload-lot tonnage is 5.6 per cent of the total and this percentage increases to 20.3 per cent for distances of 100 miles or more.

The report emphasizes that among the factors which control the proportion of total tonnage hauled by the truck are the type of commodities handled.

The following table presents a summary of the relation between motor-truck and rail tonnage according to length of haul:

PROPORTION OF MOTOR-TRUCK AND RAILROAD NET TONNAGE ACCORDING TO LENGTH OF HAUL FOR AVERAGE MONTH 1925.

	Motor Truck		*Rail C. L.*		*Rail L.C.L.*		*Total*	
Length of haul (highway miles)	*Tons*	*Per cent*	*Tons*	*Per cent*	*Tons*	*Per cent*	*Tons*	*Per cent*
Less than 20........	6,091	84.5	1,112	15.4	10	0.1	7,213	100.0
20-39	5,973	54.7	4,803	44.0	145	1.3	10,921	100.0
40-59	2,299	32.0	4,484	62.4	404	5.6	7,187	100.0
60-99	980	24.2	2,409	59.4	663	16.4	4,052	100.0
100 and over.....	157	2.3	5,280	77.4	1,383	20.3	6,820	100.0

New Luxurious Day Train of the New York Central

A new type of coach train is in service on the New York Central Railroad between New York and Buffalo. The new train will be unique in eastern railroading. One of its chief innovations will be an observation car for passengers, without extra cost. This is the first observation car ever supplied by the New York Central for coach passengers every facility for surveying at their ease the wonderful scenery of the Hudson River and Mohawk Valley. Fitted especially for this train, it is finished in warm tones of brown, with brown carpet and with duotone brown figured upholstery for the movable wicker chairs with which it is equipped.

Observation Car of New Day Train Between New York and Buffalo

In addition to the observation car, the train will have a baggage car, a smoking car, a dining car and coaches. These coaches also are of a new type, each having soft and comfortable individual seats of a new type for 82 persons. The coaches, likewise, are decorated in brown, with walnut grain finish and brown carpets in the aisles. Each coach has hot and cold running water in the wash rooms. Windows are screened.

Two uniformed porters will assist passengers with baggage and perform services. Regular New York Central dining service will be provided.

The westward section will leave New York daily at 9:30 A. M., eastern standard time, the same hour at which the eastern section will leave Buffalo. Each section will arrive at its respective terminal at the same hour, 8:15 P. M., stopping at the principal cities along the way.

Air Brake Association Meeting

On May 4 the Air Brake Association completed the work of its thirty-fifth annual convention, which was held at the Book-Cadillac Hotel, Detroit, Mich., and adjourned to meet next year at Chicago. The program consisted of a total of 13 committee reports and papers including such subjects as Triple Valve Union Gaskets—Rubber v. Leather; Main Reservoirs; Yard Air Plants; Maintenance of Steam Driven Air Compressors; What Is the Best Material for Air Brake and Air Signal Piping? Welding Locomotive Air Piping by the Oxy-Acetylene Process Excluding Dirt and Moisture from Passenger Brake Cylinders; Recommended Practice and Power Brakes for Automobiles.

Although the attendance at the convention, about 650, did not approach the record attendance of the convention held in Washington, D. C., in 1927, the exhibit of the Air Brake Appliance Association was one of the largest and most complete ever held in the history of this association.

According to the customary procedure, all of the officers were elected to the next higher position, H. L. Sandhas, general inspector, Central Railroad of New Jersey, being elected president for the ensuing year. J. E. Gardiner, general air brake inspector, Boston & Maine, was elected a new member of the Executive Committee. The newly elected officers are as follows: President, H. L. Sandhas (C. R R. of N. J.); first vice-president, W. W. White (Michigan Central); second vice-president W. H. Clegg (Canadian National); third vice-president, R. M. Long (P. & L. E.); secretary, T. L. Burton (N. Y. C.); treasurer, Otto Best (Nathan Mfg. Company). The members of the executive committee are W. F. Peck (B. & O.); C. H. Rawlings (D. & R. G. W.); E. Z. Mann (A. C. L.); E. Von-Bergan (Ill. Cent.); and J. E. Gardiner (B. & M.).

Notes on Domestic Railroads

Locomotives

The Missouri Pacific Railroad is inquiring for five 2-8-4 type locomotives.

The Southern Pacific System has ordered 10 Mallet 2-8-8-2 type locomotives from the Baldwin Locomotive Works.

The Union Pacific System has ordered twenty-three 4-12-2 type locomotives and 15 additional tenders from American Locomotive Company.

Ferrocarril de Antioquia, Colombia, has ordered four Mikado-type locomotives from the Baldwin Locomotive Works.

The Mississippi Central Railway is inquiring for 1 Mikado type locomotive.

The Weyerhaeuser Timber Company has ordered one 2-6-6-2 type locomotive from the Baldwin Locomotive Works.

The Indianapolis Union Railway has ordered an eight-wheel switching locomotive from the Baldwin Locomotive Works.

Ferrocarril de Pacifico, Colombia, has ordered 10, 4-8-0 type locomotives from the Baldwin Locomotive Works.

The Ashland, Ky., division of the American Rolling Mill Company, has ordered three, 300-hp. oil-electric locomotives, to be manufactured jointly by the Ingersoll-Rand Company, the General Electric Company, and the American Locomotive Company.

The Boston & Maine Railroad is inquiring for two eight-wheel switching locomotives.

The Canadian Pacific Railway has ordered 25 Mikado type locomotives from the American Locomotive Company through the Montreal Locomotive Works, Ltd.

The Great Northern Railway has ordered 2 electric locomotives to be built jointly by the Baldwin Locomotive Works and the Westinghouse Electric & Manufacturing Company.

The Southern Pacific System contemplates building nine locomotive tenders in its Houston, Tex., shops.

The Aluminum Company of America has ordered for its Alco power plant 2 four-wheel switching locomotives from the American Locomotive Company.

The Missouri Pacific Railroad has ordered five 2-8-4 type locomotives from the American Locomotive Company.

The Chicago & Illinois Midland Railway is inquiring for 2 Mikado type locomotives.

The Guayaquil & Quito has ordered 3 Garratt Type Locomotives from Beyer Peacock & Co., Ltd., Manchester, England.

Passenger Cars

The Paulista Railway of Brazil is inquiring for 7 sleeping cars.

The Reading Transportation Company has ordered 10 club coaches from the Mack-International Motor Company.

The Columbus & Greenville Railway has ordered two 73-ft. gas-electric rail motor cars and two 73-ft. passenger trailer cars with observation ends from the J. G. Brill Company.

The Chicago, Rock Island & Pacific Railway has ordered 5 steel horse-express cars from the American Car & Foundry Company.

The Southern Pacific System has ordered 6 dining cars and 5 compartment coaches from the Pullman Car & Manufacturing Corporation, 10 baggage cars from the Standard Steel Car Company, 25 steel coaches from the American Car & Foundry Co. and 6 baggage and mail cars from the Bethlehem Steel Company.

The Boston, Revere Beach & Lynn Railroad has taken delivery on two A. C. F. 23-passenger urban coaches.

The Canadian National Railways has issued an inquiry for 55 passenger cars.

The New England Transportation Company has ordered 15 parlor observation coaches from the American Car and Foundry Motors Company.

The New York, Chicago & St. Louis Railroad has ordered one private car from Pullman Car & Mfg. Corporation.

The Missouri Pacific Railroad is inquiring for 1 business car.

The Canadian Pacific Railway has purchased five sleeping car underframes from Canadian Car & Foundry Company, and five from National Steel Car Corporation.

The Chicago, Milwaukee, St. Paul & Pacific Railway has ordered 10 baggage cars from its own shops.

The Central of Brazil has ordered 8 sleeping cars, 2 buffet baggage cars and 10 steel passenger cars from the American Car & Foundry Co.

The Erie Railroad has ordered 25 steel suburban passenger coaches from the Standard Steel Car Company and 5 steel baggage and express cars, 3 steel baggage and mail compartment cars from the Pullman Car & Manufacturing Corporation.

The New York Central Lines has placed orders for 120 cars, distributed among the Pullman Car & Manufacturing Co., American Car & Foundry Co., Standard Steel Car Company, Osgood-Bradley Car Company, Pressed Steel Car and Merchants Despatch, Inc.

The Chicago Great Western Railroad is inquiring for 3 baggage and mail cars.

The New York, Chicago & St. Louis Railroad is inquiring for 1 business car.

The Union Pacific System is inquiring for 4 gas-electric rail motors.

The Missouri-Kansas-Texas Lines is inquiring for from 6 to 19 baggage and mail cars.

The Pacific Electric Railway is reported to have ordered 18 interurban cars and 10 passenger coaches from the St. Louis Car Company. This road also plans to recondition 198 cars in its own shops.

The Canadian National Railways is inquiring for 3 steel baggage and mail cars 63 ft. long.

Freight Cars

The South Manchurian Railway is inquiring for 20 air-dump cars of 45 cu. yd. capacity.

The Chicago, Milwaukee, St. Paul & Pacific Railway has ordered two 200-ton flat cars from the Standard Steel Car Company.

The Standard Oil Company of New Jersey is inquiring for 10 tank cars for export.

The North American Car Company has ordered 200 live poultry cars from the Standard Steel Car Company. They have also purchased 500 used tank cars, which does not affect their inquiry for 500 new tank cars.

The Wheeling Steel Corporation has ordered 16 air-dump cars from Koppel Industrial Car and Equipment Company.

The Chicago, St. Paul, Minneapolis & Omaha Railway has purchased 300 general service gondola cars from Siems-Stemble Company. They have also made inquiry for 200, 50-ton flat cars and expect to buy 250 additional freight cars.

The Wilson & Company has ordered 300 refrigerator cars from the Bettendorf Company.

The Chicago & North Western Railway is inquiring for 200 flat cars of 50-ton capacity.

The Brown Company, Berlin, N. H., has ordered 1 glass lined tank car of 5,000 gal. capacity from the General American Tank Car Corporation.

The Chicago, Burlington & Quincy Railroad is building 250 stock cars at its Galesburg plant.

The Chicago, Rock Island & Pacific Railway has purchased five horse cars from American Car & Foundry Company.

The Barrett Company has ordered 100 insulated tank cars of 10,000 gal. capacity from the American Car & Foundry Company.

The Virginian Railway has ordered 1,000 hopper car bodies of 57½-ton capacity from the Virginia Bridge & Iron Co.

The International Railways of Central America have ordered 25 flat cars and 50 gondola cars of 25 tons' capacity and 5 tank cars of 4,300 gal. capacity from the Magor Car Corporation.

The Amtorg Trading Corporation, New York, has ordered 16 30-ton flat cars from Magor Car Corporation.

The Atlantic Coast Line is inquiring for 300 freight cars.

The Wheeling Steel Corporation is inquiring for 10 gondola cars and 20 hopper cars of 70-ton capacity.

The Chicago, Milwaukee, St. Paul & Pacific Railway will accept bids for 4,650 freight and 10 baggage cars.

The Guayaquil & Quito, Ecuador, has ordered 50 box cars of 22½ tons' capacity from the American Car & Foundry Company.

The International Railways of Central America have ordered 25 flat cars and 50 gondola cars of 25-ton capacity and five tank cars of 4,300 gallon capacity, from the Magor Car Corporation.

The American Oil Company, Baltimore, Md., has ordered 2 three compartment tank cars of 6,000 gal. capacity, from the General American Tank Car Corporation.

The Kansas City, Mexico & Orient Railroad is reported to be inquiring for 100 box cars.

The Southern Cotton Oil Company, Savannah, Ga., has ordered 10 tank cars of 8,000 gal. capacity from the American Car & Foundry Co., and 10 tank cars from the General American Tank Car Corporation.

The Conley Tank Car Company has ordered 50 40-ton tank cars from American Car & Foundry Company.

Cudahy Packing Company is reported to have withdrawn its inquiry for 200 freight cars.

The North American Car Company is inquiring for 300 live poultry cars.

The Pitsburgh Coal Co. has purchased 6000 mine cars from Lorain Steel Co.

The Safety Car Heating & Lighting Company has ordered 30 special refrigerator cars without ice bunkers from the American Car & Foundry Co. These cars are to be equipped with the Silica-Gel automatic refrigeration system.

The Chicago, St. Paul, Minneapolis & Omaha Railway is inquiring for 250 stock cars.

The Missouri Pacific Railroad will build 200 automobile cars in its DeSoto, Mo., shops.

The Lehigh & New England Railroad is inquiring for 6 caboose cars.

The Seaboard Airline Railway is inquiring for 1,000 box cars of 40 tons' capacity.

The Manila Railroad is inquiring for 100 box cars of 30 tons' capacity.

The Pittsburgh & Shawmut Railroad is inquiring for 6 caboose cars.

The Illinois Central Railroad is inquiring for 2 air dump cars.

The Public Service Company of Northern Illinois, Chicago, is inquiring for 1 flat car.

The U. S. Navy Department, Bureau of Aeronautics, is inquiring for 1 tank car, for carrying Helium gas.

The Chicago, Rock Island & Pacific Railway is inquiring for 250 composite gondola car bodies.

The Montevideo Post Administration, Montevideo, Uruguay, is inquiring through the car builders for 20 open-top cars.

The Missouri-Kansas-Texas Lines is inquiring for 10 air dump cars of 20 cu. yd. capacity.

The Cambria & Indiana Railroad is having repairs made to 625 all-steel hopper cars, of 55 tons' capacity, at the shops of the Pressed Steel Car Company.

The United Porto Rican Sugar Company (San Juan, Porto Rico), is inquiring through the car builders for 22 freight cars of 20 tons' capacity.

The Southern Pacific System will build 50 caboose cars, 50 gondola cars and 500 flat cars in its own shops.

The American Oil Company, Baltimore, Md., ordered 1 three-compartment tank car of 5,000 gal. capacity, from the General Tank Car Corporation.

The Chicago, St. Paul, Minneapolis & Omaha Railway has ordered 200 flat cars from the Pullman Car & Manufacturing Corporation.

The South African Railways are inquiring through the car builders for 500 gondola cars of 20 tons' capacity, to have four wheels.

Supply Trade Notes

Thomas H. MacRae, formerly general manager, has been elected president of **MacRae's Blue Book Co.**, Chicago, Ill.

MacRae's Blue Book was founded by the late Albert MacRae and Thomas H. MacRae in 1911. Intended originally as a Buyers Guide for the purchase of railroad material and supplies, but more latterly covering the entire industrial field. The success of MacRae's Blue Book has been largely due to the guidance of Mr. MacRae who has an extensive acquaintance among railway officers, executive and engineering department heads.

During the world war, as one remembers, the various railroad employee magazines were suspended and the United States Railroad Administration Magazine created by the government to take the place of all. In this important work Mr. MacRae was appointed as special assistant to the director general of railroads and made manager and editor of the war publication. He brought into it the same force and ability and genius for detail that had characterized his activities in the business field. He had on his staff seven regional editors and 85 assistant editors, thus bringing into contact with the government railway directorate, railroad officials and employees throughout the country. Mr. MacRae held this responsible position until the close of the administration March 4, 1920, when he again took up his work on the Blue Book, and assumed editorship of the Santa Fe Magazine with which he had long been connected prior to the war.

Mr. MacRae is a former president of the Directory and Media Department of the International Advertising Association and a former member of the National Advertising Association, and is well known throughout the industrial and advertising field.

H. R. Sykes has been appointed manager of sales of the locomotive division of the **Cincinnati Car Company**, Cincinnati, Ohio.

David Thomas has been appointed manager of bar iron sales of the **Reading Iron Company**, Reading, Pa.

The Pyle-National Company, Chicago, has opened an office in the Oliver Building, Pittsburgh, Pa. **Thomas F. McGinnis** will be in charge of the office.

J. E. Heber has been appointed vice-president of the **Truscon Steel Company** in charge of Pacific Coast activities with headquarters at Los Angeles, Cal.

J. B. Dearborn has been appointed Illinois representative of the **Calumet Steel Company**, Chicago, to succeed **H. J. Elander**, resigned.

The Chicago sales office of the **Joseph Dixon Crucible Company** is now located in the Builders Building, Wacker Drive and LaSalle Street.

The Botfield Refractories Company, Philadelphia, Pa., has arranged for the distribution of its products in Toledo, Ohio, and vicinity, to be handled by the Builders & Industrial Supply Company, 4090 Detroit Street, Toledo.

M. C. M. Hatch, Technology Chambers, 8 Irvington Street, Boston, Mass., has been appointed representative in the New England territory, for the **Armspear Manufacturing Company**, New York.

J. L. Terry, for many years identified with the **Q. & C. Company**, and located at St. Louis in charge of the Southwestern territory, has been elected vice-president in charge of sales with headquarters at Chicago, Illinois.

The Pyle-National Company, Chicago, has opened an office in the Little Building, Boston, Mass., in charge of **Carl S. Geis**; the company also opened an office in the Marine Bank Building, Houston, Tex., in charge of **Alexander E. Johnson.**

George E. Cornwall has been appointed supervisor of the railway sales division of the **Heywood-Wakefield Company**, Boston, Mass.

Briggs & Turivas, Inc., has moved its general office from 110 South Dearborn Street, Chicago, to 139th Street near Western Avenue, Blue Island, Ill.

The Bassick Manufacturing Company, Chicago, plans the construction of a three-story 18 ft. by 120 ft. addition to its plant to cost $175,000.

Joseph S. King, Jr., engineer of tests of the **Bradford Corporation** has resigned to become sales representative of the **Forsyth Draft Gear Corporation** with headquarters at Chicago.

Ross F. Hayes, 50 Church Street, New York City, has been appointed general sales agent, at New York, for the **Hastings Signal & Equipment Company**, Boston, Mass.

The Standard Railway Equipment Company, the **Union Metal Products Company**, and the **Railway Metal Products Company**, have moved their offices from the Railway Exchange Building to the Shell Building, St. Louis, Mo. **A. G. Bancroft** is southwestern sales manager, and **E. G. Fredell** service engineer, at St. Louis.

Charles E. Tullar, assistant manager of the patent department of the **General Electric Company**, Schenectady, New York, has been appointed manager of the department, to succeed **A. D. Lunt**, deceased.

The Oliver Iron & Steel Corporation, Pittsburgh, Pa., has opened a new warehouse at Nineteenth and Campbell Streets, Kansas City, Mo., in charge of **W. M. Watters**, district manager. A complete stock of pole lined material will be maintained at this warehouse.

The Railroad Supply Company, Chicago, has opened an office at Room 908 States Planters Bank Building, Richmond, Va., in charge of **J. C. Duraneau.**

A. N. Willsie, formerly western sales manager of the Locomotive Stoker Company, has been placed in charge of the railway sales of the **Gunite Corporation**, Rockford, Ill.

The Foote Brothers Gear & Machine Company, Chicago, has appointed **Woodbury & Wheeler** its representative at Portland, Ore., and the **Cunningham Electric Company** its representative at Tacoma, Washington.

George F. Schlesinger, director of highways of Ohio, has resigned to become chief engineer and managing director of the National Paving Brick Manufacturers Association. The headquarters of the association which are now in Chicago, will be moved to Washington, D. C.

C. A. Heiser, formerly assistant sales manager of the **Southwest General Electric Supply Company**, Dallas, Texas, has been appointed district manager of a new office opened at 409 Browder Street, Dallas, by the **Oliver Iron & Steel Corporation**, Pittsburgh, Pa.

The A. & H. Corporation, Chicago, has been organized to engage in general railway and industrial supply business. The new company will take over the sales and service of the **E. A. Lundy Company** in the western territory. It will also handle all Aldobilt products.

The Fairmont Railway Motors, Inc., Fairmont, Minn., and **Mudge & Company**, Chicago have brought together their interests. The new company will continue the manufacture of all types of classes of both Fairmont and Mudge motor cars and other equipment. The general offices will be maintained in New York, Washington, D. C., St. Louis, Mo., New Orleans, La., San Francisco, Cal., Winnipeg, Man., and Mexico City, Mex. The officers of the new company are: chairman of the board, H. E. Wade, formerly vice-president of Fairmont; vice-chairman of the board, J. P. Dunning, formerly vice-president of Fairmont; president, Robert D. Sinclair, formerly president of Mudge & Company; vice-presidents, W. F. Kasper, formerly chief engineer and manager of sales of Fairmont and Albert C. Force, formerly vice-president and treasurer of Mudge & Company; treasurer, H. M.

Starrett, formerly treasurer of Fairmont; and secretary A. R. Fancher, formerly secretary of Fairmont. Both manufacturing plants the Mudge Plant at Chicago and the Fairmont Plant at Fairmont will continue to operate the same as heretofore.

D. A. Merriman, general manager of sales of the **American Steel & Wire Company**, Chicago, has been elected vice-president and general manager of sales. **H. B. Maguire**, assistant manager of the Detroit sales office, has been promoted to assistant to the vice-president and general manager of sales at Chicago.

E. J. Blake has been appointed engineer in charge of the car lighting section of the **American Brown Boveri Electric Corporation**, Camden, N. J. Mr. Blake was born in Newark, N. J.

The Wright Aeronautical Corporation has bought 15 acres of land and several buildings, part of the Cooke plant, of the American Locomotive Company, at Paterson, N. J. This is adjacent to the present Wright plant comprising five acres of land and buildings, that the company holds under lease.

W. J. Fendner has been appointed mechanical engineer of the **Schaefer Equipment Company**, Pittsburgh, Pa.

William M. Du Pont, Jr., of Wilmington, Del., has been elected chairman of the executive committee of the **Miller Train Control Corporation**, succeeding his father, the late William M. Du Pont.

Edward E. Gold, president of the **Gold Car Heating & Lighting Company** since its organization, has been elected chairman of the board and **Frank W. Dearborn** who has been for a long time connected with the company, was elected president to succeed Mr. Gold. **Franklin H. Smith** of the sales department, was elected assistant treasurer, all with headquarters at Brooklyn, N. Y.

The Northern Engineering Works, Detroit, Michigan, has appointed the **Interstate Supply Company**, Commercial Trust Building, Philadelphia, Pa., its district factory representative for that district.

W. J. Walsh, formerly vice-president of the **Galena Signal Oil Company**, has been appointed special representative of the **Standard Oil Company of Indiana**, with headquarters at Chicago.

R. J. McComb, western manager of the **Q and C Company**, at Chicago, has resigned to become sales manager of the **Woodings Forge & Tool Company**, Verona, Pa.

The Sargent Company, Chicago, has moved its office and factory from 625 West Jackson Boulevard, to 2073 Southport Avenue. In addition to its standard line the company has taken on a new line of steam pressure gages.

J. V. Moore, formerly with the **Simonds Saw & Steel Company**, is now representing **The Billings & Spencer Company**, Hartford, Conn., in the states of Pennsylvania, Delaware and New Jersey. Mr. Moore's headquarters are at Huntington, Pa.

George C. Scott, vice-president of the **United States Steel Products Company**, New York, has been elected president, succeeding **E. P. Thomas**.

L. C. Bihler, traffic manager of the **Carnegie Steel Company**, Pittsburgh, Pa., has been appointed an assistant to president and general traffic manager; **W. S. Guy**, assistant traffic manager; **G. W. Seaman** and **C. W. Trust** have been appointed traffic managers.

The Fulton Iron Works, St. Louis, Mo., has bought the **Foos Engine Company**, Springfield, Ohio, makers of Diesel engines of from 60 to 300 hp., according to an announcement of **Harry J. Steinbreder**, president of the Fulton Company.

The Westinghouse Union Battery Company, Swissvale, Pa., has been sold to a new company known as the **Wubco Battery Corporation**, recently organized to take over the equipment, inventory, sales outlets and good will of the Westinghouse Union Battery Company. **J. L. Rupp** is president of the new company.

The Ohio Steel Foundry Company, Lima, Ohio, has given a contract to **The H. K. Ferguson Company**, Cleveland, for the foundry unit to cost with equipment, $75,000. Additional equipment for the manufacture of locomotive castings and other heavy steel products will be provided in the new building.

The partnership interest of **W. O. Washburn** in the **American Hoist & Derrick Company** has been purchased and taken over by **Frank J. Johnson**, the senior partner and one of the founders. The business will be continued as the American Hoist & Derrick Company under the form of a corporation with **F. J. Johnson**, as president and treasurer, **Howard S. Johnson**, vice-president, in charge of production.

Items of Personal Interest

R. H. Flynn, superintendent of motive power of the Northern division of the Pennsylvania Railroad, has been appointed superintendent of motive power of the Western division. He succeeds **J. L. Cunningham** who has been promoted to general superintendent of the Western division of the Pennsylvania.

William A. Carlson, general foreman of the New York, Chicago & St. Louis Railroad at Fort Wayne, Ind., has been appointed general master mechanic of the Erie Railroad with headquarters at Hornell, N. Y.

R. G. Henley, assistant to the superintendent of motive power of the Norfolk & Western Railway with headquarters at Roanoke, Va., has been appointed superintendent of motive power, succeeding **A. Kearney**, deceased, with headquarters at the same point. **J. J. Barry**, general master mechanic at Roanake has been appointed assistant to the superintendent of motive power, replacing Mr. Henley. **O. F. Hark**, master mechanic at Portsmouth, Ohio, has been appointed general master mechanic at Roanake. He will be succeeded by J. L. Barry, master mechanic at Blue Field, W. Va. **T. L. Brown**, general foreman at Lambert Point, Va., replaces Mr. Barry as master mechanic at Portsmouth.

R. Reed, master mechanic on the Pennsylvania Railroad at Fort Wayne, Ind., has been appointed superintendent of motive power of the Northern division succeeding **R. H. Flynn**, transferred.

Don Nott, assistant master mechanic on the lines of the Chicago, Burlington & Quincy Railroad east of the Missouri River at Galesburg, Ill., has been appointed acting master mechanic at Creston, Iowa, replacing **H. G. Kastlin**, who has been given a furlough.

H. G. Huber, assistant engineer of motive power in the Central region of the Pennsylvania Railroad with headquarters at Pittsburgh, Pa., has been appointed master mechanic of the Monongahela division, with headquarters at Uniontown, Pa.

Harold H. Haupt has been promoted to superintendent of motive power of the Northwestern division of the Pennsylvania Railroad with headquarters at Chicago, Ill.

J. E. Brower, master mechanic on the Central region of the Pennsylvania, with headquarters at Pittsburgh, Pa., has been transferred to Ft. Wayne, Ind., with jurisdiction over the Ft. Wayne, the Grand Rapids and the Logansport divisions.

H. Hickenbotham, car foreman in the Western region of the Canadian National at Port Mann, B. C., has been promoted to general car foreman of the British Columbia district, with headquarters at Vancouver, B. C.

New Publications

Books, Bulletins, Catalogues, Etc.

The Proceedings of the American Society of Testing Materials. The proceeding of the Society for the year of 1927 has been issued in two parts.

Part I (1142 pages) contains the annual reports of 44 standing committees on Ferrous Metal, Effect of Temperature on the Properties of Metals, Non-Ferrous Metals, Cement, Ceramics, Concrete, Drain Tile and Specifications for Concrete Drain Tile, Gypsum, Lime, Preservative Coatings, Petroleum Products, Road Materials, Coal and Coke, Waterproofing Materials, Electrical Insulating Materials, Rubber Products, Textile Materials, Thermometers, Methods of Testing and Nomenclature and Definitions; 88 tentative standards which have either been revised or are published for the first time; annual address of the President and the annual Report of the Executive Committee.

Part II (564 pages) contains 33 technical papers with discussion. These contain valuable information on results of investigations by experts in the field of engineering materials including the fatigue of metals, the effect of temperature on the properties of metals and investigation on the corrosion-fatigue of metals, and a Symposium on Field Control of the Quality of Concrete. Mention should also be made of the many other papers on cement and concrete, and on bituminous mixtures, rubber, fire tests of combustible materials, and a number of papers of interest in connection with the testing materials, and describing new testing apparatus.

The Proceedings is published by the Society of which C. L. Warwick is Secretary. Address 1315 Spruce St., Philadelphia, Pa.

Embrittlement of Boiler Plate is the title of Bulletin No. 117 which has just been issued by the Engineering Experiment Station of the University of Illinois. The authors are Samuel W. Parr and Frederick G. Straub.

With the modern operation of steam boilers at high ratings and increased pressures there has come into use a type of boiler water which has been under suspicion for some time as the possible cause for embrittlement and cracking of the plates. The evident increase in the number of cases of such embrittlement emphasized the need of making a further study of the problem beyond that covered in Bulletin No. 94 of the Engineering Experiment Station of the University of Illinois, Published in 1917. In 1924, therefore, the investigation was resumed and the results of the first eighteen months' study were published in Bulletin No. 155.

Bulletin No. 177, just published, contains a record of the data secured since the publication of Bulletin No. 155, as well as a résumé of the entire three years' work on embrittlement. The work performed in connection with this investigation consists of the collection of information concerning failures, apparently due to embrittlement, from boiler manufacturers, boiler users, and the steam boiler insurance companies; and conducting tests either in the laboratory or at plants where embrittlement of boilers has occurred.

Some of the results obtained were as follows: In the cases of embrittlement investigated neither the design nor the workmanship of the boilers was responsible for the trouble; no fault could be found with the material of the boiler plate; apart from the nature of the feed water used the operation of the boilers was satisfactory; an alkaline condition of the boiler water, with a low sulphate content, was found in all cases of embrittled boilers, the only material found in these boilers which has been shown to have the effect of embrittling stressed steel was sodium hydroxide; increasing the sulphate content was found to be effective in stopping or inhibiting embrittlement; and new embrittlement inhibiting agents were developed.

Copies of Bulletin No. 177 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Illinois.

Titanium in Rail Steel—In a 26-page bulletin on the subject of ferro carbon-titanium in basic open-hearth rail steel, the Titanium Alloy Manufacturing Company, Niagara Falls, N. Y., presents a review of this subject, dealing with the method of titanium treatment, the effect of titanium on the steel, and the wearing qualities of titanium treated rails. It also includes detailed service records of titanium treated rails, showing the effect of the treatment in minimizing the various classes of rail failures.

Electrical Equipment for Railway Signaling is the title of a new 24-page circular that has just been issued by the Westinghouse Electric & Manufacturing Company. The publication is devoted to a description of equipment and its uses in the signal system. The contents include automatic switching, choke coils, cutouts, disconnecting switches, fuses, fuse blocks, insulating materials, lightning arresters, motor-generator sets, porcelain insulators, portable instruments, safety switches, transformers and wiring details. The circular is profusely illustrated.

Copies of the circular may be obtained from any Westinghouse District Office or by applying to the Transportation Section, advertising Department at East Pittsburgh.

Lubrication for Safety and Economy is the name of a new 20-page booklet just published by E. F. Houghton & Company, Philadelphia, Pa. It relates to Houghton's Absorbed Oils and the Gun-Fil Lubricator. It explains in detail why a proper oil feed is essential to greatest economy in lubrication. This, for instance, is the way the first page begins: "Lubricating oil is no different from fuel and food. In order to function best it must be fed best."

E. F. Houghton & Company do not manufacture oil feed cups or lubricators, but they do recommend the use of the Gun-Fil Lubricator for feeding their oils. The lubricator they recommend is simple in construction, easy to install and to fill, and is applicable to a wide variety of bearings. The booklet is liberally illustrated with photographs of actual installations. The last pages are devoted to "Ten Reasons Why You Should Use Houghton's Absorbed Oils," and to a complete list of Houghton's Distributors covering the entire world.

Functions of a Sales Manager. The Policyholders Service Bureau of the Metropolitan Life Insurance Company has recently issued a booklet with the foregoing title. In it a sales manager in discussing the functions of his office gives the opinion that is generally believed that it is wiser to hire and train raw material than attempt to secure a rival's star salesman.

The booklet, Functions of a Sales Manager, is a compilation of opinions on the subject, points out that no general agreement exists as to what constitutes the functions of the official in the present-day organization. From the material contributed to the report by leading business organizations through the country, however, a basic classification of duties from a practical standpoint has been drawn up. The selection of salesmen, their training, methods of compensation, sales promotion, sales direction, sales research, advertising and service are described in detail in their relations to the functions of the sales manager.

The report is illustrated with sales organization charts of a number of companies and with salesmen's forms and blanks. Copies may be secured from the Policyholders Service Bureau on request.

Locomotive Feedwater Heating. The Superheater Company, 17 East 42nd Street, New York, has issued a booklet giving hitherto unpublished data in regard to the advantages of the feedwater heater. It gives simple calculations based on an analysis of test data that shows the extent to which the feedwater heater increases boiler evaporation.

It also gives the reasons why locomotive feedwater heating improves locomotive performance and is a necessity for efficient power.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XLI 136 Liberty Street, New York, June, 1928 No. 6

New 2-8-4 Type Locomotive for the Boston & Maine

Exert a Tractive Force of 81,400 Pounds and Are Equipped With Coffin Feedwater Heater

The Lima Locomotive Works, Inc., has delivered to the Boston & Maine Railroad twenty 2-8-4 type locomotives designed for fast freight service or for passenger service if needed. For the latter service, steam heat and air signal equipment has been applied so that the engines may be readily used in incidental passenger service.

The new engines are of the same general design as the Lima A-1 type locomotive, the principal difference being in the total weight of the engines in working order and the total evaporative heating surface. The A-1 engine weighs 385,000 lb. and the new Boston & Maine locomotives weigh 393,000 lb. The accompanying table giving a comparison of the principal dimensions of the A-1 and new B. & M. locomotives shows that the latter has a slight increase in the total evaporative heating surface which is attributed to the fact that the new engines are equipped with two Nicholson thermic syphons. The rated tractive force of the two designs are the same, 69,400 lb. With the booster which drives on the rear axle of the trailing truck, the tractive force is 81,400 lb. The performance record of the Lima A-1 engine was published in the October, 1925, issue of Railway and Locomotive Engineering.

The new power will provide faster and more flexible operation and at the same time a more economical record in fuel and maintenance costs. For the present the engines will be used on the Fitchburg division, between Mechanicville, N. Y., and Boston, Mass., but on completion of bridge improvements they will be also operated over the Portland division, making the through runs of approximately 300 miles between Mechanicville, N. Y., and Portland, Maine.

The ruling grade on the Fitchburg division, westbound, is near Gardner Mass., about midway between Mechanicville and Boston. Here the grade is 12 miles long and averages about 1.22 per cent. Eastbound, the ruling grade is .91 per cent. There is no grade problem on the Portland division.

These locomotives without the services of helper engines will reduce the running time of a 75-car train between Mechanicville and Boston, a distance of 210 miles, by two hours.

New 2-8-4 Type Locomotive of the Boston & Maine Railroad Built by the Lima Locomotive Works, Inc.

As previously stated, the total weight of the engines is 393,000 lb., of which 250,200 lb. is on the driving wheels and 104,000 lb. on the four-wheel trailing truck. The boiler pressure is 240 lb. and the maximum cut-off is 60 per cent.

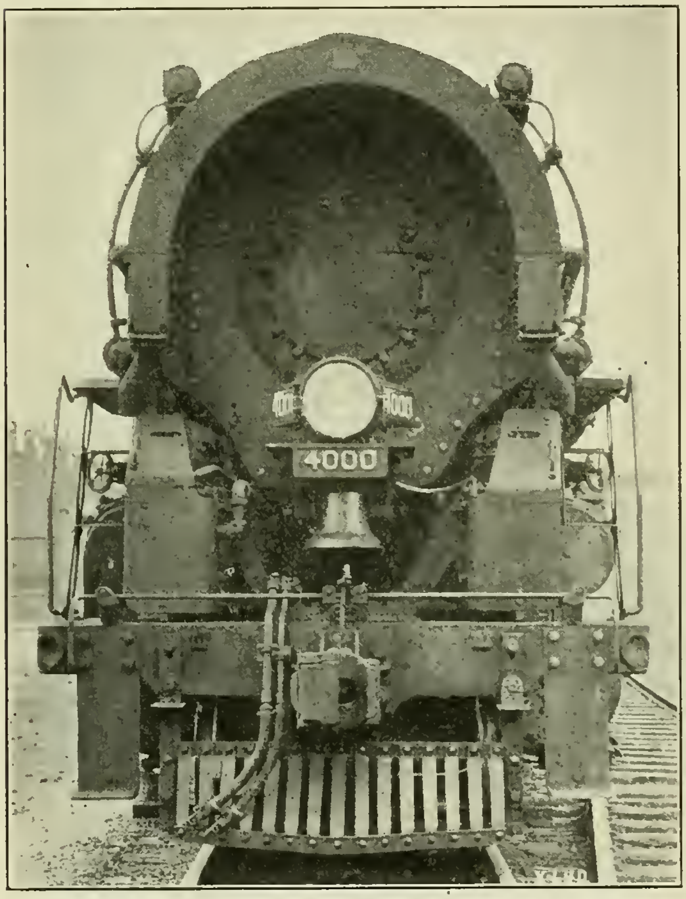
Aside from the size of the firebox, which has a grate area of 100 sq. ft., the boiler does not differ materially from the usual type of design. It is of the extended wagon top type, the first course of which is 88 in. in diameter and the third course 94 in. The boiler is provided with a Type E superheater and Chambers front-end throttle. The dry pipe is provided with a main shut-off valve in the dome for use in case repairs on the throttle or superheater are necessary when the boiler is under pressure.

There are two turrets from which steam is distributed to the auxiliaries, both located over the top of the boiler just in front of the cab. One of these furnishes saturated steam to the injector, lubricators and steam heat system. The other draws superheated steam from the throttle pipe connection to the superheater header for use in the air compressor, stoker, booster, headlight turbine, blower and whistle.

The petticoat pipe in the smokebox has a blower arrangement in the bottom periphery instead of connecting the blower to the exhaust nozzle, which is of the Goodfellow type. Owing to the location and construction of the steam dome incidental to the front-end throttle arrangement, an auxiliary inspection dome is located on the course next to the firebox to facilitate interior boiler inspection.

The boiler lagging studs are welded to the boiler instead of being tapped in. The lagging is covered with a jacket made from copper-bearing steel.

The boiler is supported on frames made of manganese-nickel cast steel. The pedestal toes are of minimum depth and made wide enough to take collared pedestal studs which, in conjunction with the outer pedestal bolts, hold



Front View of Locomotive No. 4000 of the Boston & Maine

the pedestal cap in place. This arrangement draws the cap directly to the toes and eliminates the fulcrum effect at the toe and consequent flexure of the cap found in the usual application. The key arrangement at the frame and saddle fit is the double wedge type with a bolt.

All of the pedestals are equipped with Franklin automatic wedges with parallel-faced floating plates and single taper wedges. The shoes are made of special bronze.

The spring saddles on the driving boxes are designed to bear on the ends and not in the center. This feature assures a stable setting of the saddle and eliminates uneven wear on the saddle seat and consequent relining with inserted plates. Eventual wear can be taken care of by building up with autogenous welding and then machining.

The main rods, side rods, driving axles and crank pins are made from normalized carbon-vanadium steel. The rod arrangement is the Lima tandem extended main rod type with floating bushings on the main pins.

The locomotives are equipped with commonwealth ashpans with horizontal sliding doors and a mechanical dump. This ashpan is supported in the frame of the articulated four-wheel trailing truck, on which is also mounted a Franklin booster. The Franklin power reverse gear is synchronized with the booster.

Water is supplied from the left side of the tank through the Coffin feedwater heater and from the right side through a non-lifting inspirator. A thermometer well is located in the feedwater heater delivery pipe to facilitate taking feedwater temperatures when desired. The shut-off valve in the pipe from the cylinder exhaust to the

Comparison of Lima A-1 and New Boston & Maine Locomotives of the 2-8-4 Type

Type	A-1	B. & M.
Cylinders, diameter and stroke	28 in. by 30 in.	28 in. by 30 in.
Cut-off in full gear	60 per cent.	60 per cent.
Boiler pressure	240 lb.	240 lb.
Weights in working order:		
On drivers	248,200 lb.	250,200 lb.
On front truck	35,500 lb.	38,800 lb.
On trailing truck	101,300 lb.	104,000 lb.
Total engine	385,000 lb.	393,000 lb.
Diameter drivers	63 in.	63 in.
Heating surfaces:		
Firebox, incl. arch tubes*	337 sq. ft.	405 sq. ft.
Tubes and flues	4,773 sq. ft.	4,726 sq. ft.
Total evaporative	5,110 sq. ft.	5,131 sq. ft.
Superheating	2,111 sq. ft.	2,111 sq. ft.
Comb. evaporative and superheating	7,221 sq. ft.	7,242 sq. ft.
Grate area	100 sq. ft.	100 sq. ft.
Rated tractive force:		
Engine	69,400 lb.	69,400 lb.
Engine and booster	82,600 lb.	81,400 lb.
Factor of adhesion	3.58	3.6

Principal Dimensions, Weights, Etc., of Boston & Maine 2-8-4 Type Locomotves

Railroad	Boston & Maine
Type of locomotive	2-8-4
Service	Fast freight
Cylinders, diameter and stroke	28 in. by 30 in.
Valve gear, type	Baker, long travel
Valves, piston type, size	14 in.
Maximum travel	8¾ in.
Outside lap	2⅝ in.
Exhaust clearance	1/16 in.
Lead in full gear	¼ in.
Cut off in full gear, per cent	60
Weights in working order:	
On drivers	250,200 lb.
On front truck	38,800 lb.
On trailing truck	104,000 lb.
Total engine	393,000 lb.
Tender, loaded	216,400 lb.
Wheel bases:	
Driving	16 ft. 6 in.
Total engine	41 ft. 8 in.
Total engine and tender	80 ft. 3¾ in.
Wheels, diameter outside tires:	
Driving	63 in.
Journals, diameter and length:	
Driving, main	12 in. by 14 in.
Driving, others	11 in. by 13 in.
Front truck	6½ in. by 12 in.
Trailing truck	Front, 6½ in. by 12 in. Rear, 9 in. by 14 in.
Boiler:	
Type	Wagon top
Steam pressure	240 lb.
Fuel	Bituminous
Diameter, first ring, outside	88 in.
Firebox, length and width	150⅛ in. by 96¼ in.
Arch tubes, number and diameter	2—3½ in.
Tubes, number and diameter	86—2¼ in.
Flues, number and diameter	204—3½ in.
Length over tube sheets	20 ft.
Grate area	100 sq. ft.
Heating surfaces:	
Firebox	284 sq. ft.
Arch tubes and two syphons	121 sq. ft.
Tubes	1,008 sq. ft.
Flues	3,718 sq. ft.
Total evaporative	5,131 sq. ft.
Superheating	2,111 sq. ft.
Comb. evaporative and superheating	7,242 sq. ft.
Special equipment:	
Superheater	Type E
Feedwater heater	Coffin, Type C
Stoker	Dupont Simplex, Type B
Booster	Franklin
Tender:	
Style	Rectangular
Water capacity	12,000 gal.
Fuel capacity	18 tons.
General data estimated:	
Rated tractive force, 60 per cent	69,400 lb., with booster, 81,400 lb.
Factor of adhesion	3.6.

feedwater heater is equipped with a locking device to insure the valve remaining open at all times while in service.

The locomotives are equipped with eight-feed, force-feed lubricators for lubricating the steam chests, guides and air compressor steam cylinders. A hydrostatic lubricator provides lubrication for the Simplex Type B stoker and booster. All of the valve gear bearings are provided with Bassick Alemite high-pressure grease fittings. Speedee grease cups are used on the rods.

Barco flexible metallic joints are used for the air and steam heat connections between the engine and tender and the air signal and steam heat terminals at the rear of the tender are secured on movable supports which afford flexibility in lateral movement.

Pittsburgh & Lake Erie New Instruction Car

The Pittsburgh & Lake Erie Railroad Company has recently completed and placed in service a new air brake instruction car in which the equipment has been arranged and installed uniquely under the supervision of R. M. Long, Air Brake Supervisor, and N. H. Ward, Assistant Air Brake Supervisor.

The car, numbered X-101307, contains facilities for instruction in the maintenance and operation of air brakes, steam heat, and automatic train control. The lecture compartment of the car has a seating capacity for a class of fifty. The instruction end of the car has a complete E. T. equipment with sectional valves, etc., so arranged

Interior View of Pittsburgh & Lake Erie Railroad Company's New Instruction Car

that the class can easily visualize the relation of each piece of equipment. The eight and one-half inch cross compound air compressor, injector, lubricator, water glass cocks, etc., are of sectional construction so that the observer can see the actual construction of each part and how it operates. A No. 6 distributing valve and a K-1 triple valve are in full view of the class. These are tandem valves having a sectional portion connected to the operating valve so that the operation of the piston, valve and various parts can be readily observed.

The car was built at the McKees Rocks passenger coach shop under the supervision of S. Lynn, Superintendent of Rolling Stock, and W. C. Lang, Master Car Builder.

Blue prints and diagrammatices of piping arrangements were drawn up by William H. Brenkhoff in the office of the Mechanical Engineer, H. Courtney. The car is for the purpose of instruction and examination of enginemen, firemen, conductors, brakemen, and all employes whose duties require them to be in touch with the maintenance and operation of all classes of train service.

The braking equipment in the car consists of complete sets for twenty freight cars and eight passenger cars, in addition to the engine and tender brake, all of standard size. The twenty standard-size freight brake cylinders and auxiliary reservoirs are secured to the side of the car all on one side and in a straight line. The twenty freight brake cylinders were arranged in connection with four sixteen by seventy-two inch volume reservoirs, four vent valves, and four one and one-fourth inch non-return check valves with three one-eighth inch orifices drilled in check valves so as to demonstrate one, twenty-five, fifty, seventy-five, or one hundred cars in service or emergency application. This equipment is complete with retainers and release valves. Each cylinder auxiliary reservoir is equipped with pressure gauges, and piston travel can be adjusted to various lengths.

The eight passenger car equipments are secured to the side of the car all on the opposite side from the freight equipment in a line. The large reservoirs are secured to the floor and the smaller ones to the side of the car. The eight sets consist of one P-M, one L-N, one P-C, and five UC-12B equipments complete. A volume reservoir sixteen by forty-eight inches, with a vent valve between the seventh and eighth cyliders, demonstrates cars one to seven and fifteen.

The car is also equipped with a complete six-car passenger train signal equipment which together with a volume reservoir ten by thirty-three inches for five cars demonstrates the first, sixth and eleventh cars. The car also has a demonstrating rack for Vapor Thermostatic Heating System, a set of charts and a single car testing device for freight cars.

Qualification cards are issued from the instruction car to employes who have passed the examination required by this company.

In addition to the instruction room there is an office with a large sofa, four chairs, steel filing case, flat-top desk, wardrobe, drinking water container and a lavatory. The lavatory is equipped with a toilet and a washstand with hot and cold water. The office furnishings and office are finished in mahogany. The office end of the car has an observation platform. The instruction room is finished in ivory enamel to the top of the windows. The deck and ceilings are finished in light gray enamel, and the equipment is painted black.

The car is heated by the Vapor car heating system. It is seventy feet over end sills, has steel underframe, cast steel body bolster, six-wheel steel trucks and clasp brakes. The car weighs 169,350 pounds and is equipped as follows:

800 feet, one and one-fourth inch train line for freight brake.

640 feet, one and one-fourth inch train line for passenger brake.

480 feet, three-fourths inch signal line.

All one and one-fourth train line is underneath false floor.

The signal line three-fourths inch pipe is on the passenger side of car above the steam heat line. The brake for car itself, six-wheel class brake U. C. equipment.

UNDER CAR

4 Volume reservoirs 16 by 72 inches.

4 One and one-fourth inch check valves for 20 cars each with 4 vent valves for freight equipment.

1 Volume reservoir 16 by 48 inches, for 7 cars each with 1 vent valve for passenger equipment.

2 Main reservoirs 20½ by 102 inches.

1 Battery box.

4 Steam heat regulators.

1 Hot water regulator.

INSIDE OF CAR

(Freight Side)

2 Driver brake cylinders 12 by 12 inches.
1 Tender brake cylinder, 10 by 12 inches.
1 Freight brake cylinder 10 by 12 inches and reservoir attached.
19 Freight brake cylinders 8 by 12 inches and reservoir attached.
1 Single car testing device with 45 feet of 1¼ train line.
1 K-1 triple valve in tandem with one valve sectioned showing the movements of the valves.
1 Complete set of automatic train control.
1 Sectional freight cylinder.

INSIDE OF CAR

(Passenger Side)

1 Volume reservoir 10 by 33 inches for five cars for train line.
1 Set of P-M passenger brake equipment.
1 Cylinder 10 by 12 inches with P-1 triple valve.
1 Auxiliary reservoir 12 by 27 inches.
1 Set of L-N passenger brake equipment.
1 Cylinder 12 by 12 inches with L-2-A triple valve.
1 Auxiliary reservoir 12 by 33 inches.
1 Supplementary reservoir 16 by 48 inches.
1 Set of P-C passenger brake equipment.
1 Cylinder 12 by 12 inch emergency.
1 Cylinder 14 by 12 inch service.
1 Control valve.
1 Emergency reservoir 14 by 33 inches.
1 Service reservoir 16 by 48 inches.
5 Sets of U-C Passenger Brake Equipment.
5 Cylinders 14 by 12 inches.
5 U-12 Universal Valves, 1 U.C. 12B.
5 Auxiliary reservoirs 10 by 33 inches.
5 Service reservoirs 12 by 33 inches.
5 Emergency reservoirs 18½ by 42 inches.
2 Air gauges on all sets and 1 U-C equipment has four gauges and a slack adjuster.
1 8½ inch cross compound sectional with No. 54 air strainer sectioned.
1 11 by 7 by 12 inch pump for boosting air from shop pressure to 130 pounds.

One Locomotive Moves 189 Cars

According to a report of the Virginian Railway a record movement for westbound freight trains between Victoria and Roanoke, Va., a distance of 123 miles was recently made by locomotive No. 806 of that road when it hauled nine loaded and 180 empty cars through in eight hours and ten minutes. The train was 7,848 feet long and weighed 4,500 tons. The actual running time, with delays deducted, was seven hours, six minutes (17.32 m.p.h.), the delays being as follows: Fifteen minutes, Victoria, double over; 19 minutes at Phenix to meet an eastbound train; 15 minutes at Seneca for coal and water and 15 minutes because stopped by signals at the Norfolk & Western Interlocking, Roanoke.

Locomotive No. 806 is a Mallet, 2-10-10-2, class AE, weight 684,000 lb.; weight on drivers, 617,000 lb.; tractive effort 147,200 lb. There are in the 123 miles between Victoria and Roanoke over 200 curves. The grade ranges from level to 0.2 per cent ascending, except for about 25 miles of the distance where the ascent is 0.6 per cent, the curves being compensated.

These Mallet locomotives move coal trains eastward weighing 13,500 tons, the maximum grade being 0.2 per cent.

A Solution of the Branch Line Problem

By LESLEY C. PAUL, Westinghouse Electric & Manufacturing Co.

The branch line has always been a problem with many railroads—in fact it is probably safe to say with most railroads. And in many cases there is a family of problems because there exists a family of branch lines.

It may be that the branch was built in "halcyon" days—which no longer exist. Perhaps for a time the line actually paid, but now the profits have slipped away into the red. Perhaps even now the freight service pays but those profits are offset by a losing passenger business. Whatever the case may be the fact remains that most branch lines have been operated in the red.

Steam equipment which has become obsolete on the main line has been relegated to the branch where it is continued in service at an exorbitant cost for maintenance and an unwarranted expense for operation. And yet the earnings would not permit an expenditure for new and more efficient steam equipment for the unprofitable branch—the baby white elephant fast growing into a real menace to the whole "show."

But now a change is taking place. Today the railroads of this country are solving their problems of power by finding the most efficient "tool" for their use; by adapting the most economical power to their needs. In fact, this problem is being solved by all of our industries in one way or another, but by none more effectively than by the steam railroads.

This search for more efficient "tools" was responsible some years ago for the advent of the gas-electric rail car to solve certain traffic problems. On a branch line of one railroad, a deficit of $36,000 was changed into a profit of $102,000 by substituting gas-electric rail cars for steam trains.

This particular case, though a striking one, is by no means unique. Due to the various operating economies made possible by these efficient "tools" of transportation, many other railroads have been able to show profits instead of losses by using them. Records covering many such instances are available.

The gas-electric rail car is no novelty. The Westinghouse Electric and Manufacturing Company started to build equipment for gas-electric rail cars in 1902 and by 1912 had completed 70. Some of these are running today. However, due to the limited horsepower of these early cars; the state of the art of gasoline engine design; the maintenance difficulties existing at that time; and to other reasons, little interest was taken in this form of motive power until after the war.

Then radical changes occurred in many of the conditions affecting the gas-electric car. On the one hand, the mechanical and electrical equipment of the car was developed to a high state of excellence; while on the other, many branch railroad lines, which had previously been profitable, went into red because of rising costs and dwindling traffic.

The railroads of this country, like every other progressive American industry, are constantly analyzing every detail of their operations and are improving the efficiency of their methods at every opportunity. It is this process which has brought the gas-electric car into prominence during the past few years; it provides a solution for the lean traffic problem in many cases.

And so today thirty railroads in the United States are operating 134 gas-electric cars equipped by Westinghouse and involving 162 units of equipment. Among these are the Great Northerns; New York Central; Big Four; Reading; Chicago & Northwestern and Chicago, Milwaukee, St. Paul & Pacific. The officials of all of these railroads are enthusiastic about the future possibilities of the gas-electric car. Here is what they say:

One of the Twenty-five Gas-Electric Cars in Service on the Great Northern Railway

Mr. Ralph Budd, President of the Great Northern, which operates 25 gas-electric cars, believes the use of this type of motive power will increase and that they reduce the cost of operating passenger train service. He says:

"The continuing decline in local passenger earnings is now quite generally acknowledged to be due to the almost universal use of the automobile for short trips. Railway companies have used two methods for meeting the situation:

"First. Some of them have increased their service and reduced their rates on the theory that people would return to railway travel if rates were lower. My observation is that this method has been unsuccessful and is costing the railways that are pursuing it a great deal of money.

"Second. Some railways have sought to remove unprofitable local passenger trains, wherever it could be done, on the theory that the lack of patronage is conclusive evidence of the preference of the public for other means of local transportation. These railways have also, wherever possible, substituted more economical and smaller units of transportation for those essential local passenger runs which could not be discontinued.

"The gas-electric rail car is one of the means used to this end, and the motor bus on the highway is another. The Great Northern has in use 25 gas-electric cars, which make nearly 1,500,000 train miles per year. The gas-electric car, of course, has a good deal of the inflexibility inherent in railway service, because it is confined to the track and stops at railway stations which are on railway right of way, and, therefore, some distance from stores, hotels, residences, etc. I do not think that the use of gas-electric rail cars will attract or hold any considerable travel to the railways, but where they afford appropriate accommodations they will reduce the cost of operating such passenger train service as must be maintained for public convenience.

"I think the use of gas-electric rail cars will be increased, because I believe more of the railways will come to believe that the only means for meeting their greatly reduced passenger revenue is by decreasing the local service and providing such as must be maintained in the most economical manner rather than by attempting to recover the loss by maintaining unprofitable train service and lowering rates."

According to Mr. F. H. Hardin, Assistant to the President of the New York Central, which system operates or has on order a total of 37 gas-electric rail cars, the use of this equipment has resulted in a "material saving in operation." He says:

"The New York Central Railroad has at present in service 15 cars and an additional 10 on order not yet delivered. In addition the New York Central System Lines has 12 cars now in service.

"The use of these cars is the result of the falling off of passenger traffic on certain branch line territories, with the result that the operation of steam trains has become in these days very expensive. It has, therefore, been found possible to meet the existing service by the introduction of the motor rail car, which has resulted in most cases in a material saving in operation.

"The cars now in use are not uniform in design, but vary in accordance with service requirements. Inasmuch as these requirements vary to a considerable extent, decision to operate a rail motor car is based on careful analysis of each particular situation.

"Up to date the operation of these cars has been satisfactory."

Mr. C. S. Millard, General Manager of the Big Four finds the future for the gas-electric car very bright. He says:

"The experience we have had on the Big Four in the operation of gas-electric motor cars for handling branch line passenger traffic and local passenger traffic on main lines has resulted in a material saving in operation. The cost of operating gas-electric cars is only [illegible] per cent of the cost of steam service.

"We have not been able to increase the volume of traffic on the local trains for the reason that the private automobile and bus line competition is very strong, and there has been a gradual decrease in local traffic, not only in the territory served by the Big Four, but generally throughout the country; therefore, it behooves the Operating Officers to reduce the cost of operation to offset this reduction in revenue. This can be done by the use of motor cars to a considerable extent.

"In branch line territory where the highways are not well developed, undoubtedly the use of motor cars results in the handling of the traffic at a reduced cost, thereby obviously resulting in an increase in the net income, even though additional traffic is not obtained.

"At the present time I may say that the gas-electric cars are very dependable, our experience being that they have operated 87 per cent of their potential mileage.

"In my opinion, the future is very bright for the extension of this service, particularly on branch lines."

Gas-Electric Car of the New York Central Lines

On the Reading the substitution of gas-electric cars has resulted in "very material savings" and further extension of this service is contemplated. Mr. F. M. Falck, General Manager of the Reading Company has this to say about gas-electric cars:

"Gas-electric rail car operation on the Reading lines was inaugurated in 1925, by the purchase of one car for use on the Trenton Branch, operating between Trenton and Trenton Junction, a distance of 3.7 miles, and operating twenty-one round trips each twenty-four hours.

"In 1927, three additional gas-electric cars were purchased, operating all local service between Trenton Junction and Bound Brook, a distance of twenty-seven miles, combined with the Trenton Branch Service.

"These cars have been in successful operation in lieu of all local steam service and have been operating with three cars and a spare, an aggregate of between fourteen and fifteen thousand miles per month.

"Two additional cars of the multiple power plant type are on order and will be delivered about July 1, for use between Wilmington and Reading, a distance of sixty miles, and the Reading Company has in contemplation further extension of this class of service on various Branch lines.

"The substitution of this equipment for steam service has resulted in very material saving in operating costs without reduction in service.

"The substitution of this class of equipment has been commented upon favorably by our patrons."

The Chicago & North Western, operating 15 cars and with 10 more on order, finds gas-electric cars "reliable and satisfactory" and "money savers." Mr. George W. Hand, Assistant to the President of that company says this:

"The North Western began using gasoline-electric self-propelled passenger cars in July, 1925, when one car of this type was placed in daily service between Milwaukee and Adams, Wisconsin, where it made a round trip of 249 miles. Three similar cars were added in 1926 and five in 1927. Six more have been added this year (1928) and ten more are being built and will be in service by the end of the year.

"These cars are all alike in general features but have each been planned for some particular run and have had length, floor plans and space arrangement made to suit the requirement of the service. The cars in service up to this time have been equipped with what is known as the single unit power plant and have been placed in local runs, mostly on branch lines where the service did not call for more than a one or two car train. Some of the cars now being built will have dual power plants and will be used in somewhat heavier service, of similar character, however.

"They have been distributed widely over the system so that they now encounter diversified operating conditions. We have found them to be reliable and satisfactory and well adapted to the performance of the kind of service these runs require whenever it does not vary too much from day to day and from season to season and does not call for too much variation in train consist to permit keeping it within the limits of the capacity of the power plant carried. Where these conditions are found and where there is mileage enough to the run so that no other train or train crew can cover it, these cars are money savers. The relation between the costs of operating trains handled by these cars and the corresponding costs of steam operation vary with numerous factors and range from a cost per train mile for gasoline-electric as low as one-half to as high as three-fourths the cost of steam train operation. Obviously, the relation of these costs depends in a great measure upon the relation between the cost of gasoline and the cost of coal. Lately this has been very favorable to gasoline. Another factor is the relative man-hours required, which also has been up to this time in favor of this type of equipment.

"It is apparent, also, that the full value of this type of equipment would be greater if it were adaptable to a wider range of power requirements at justifiable investment costs. If a branch line service could be completely motorized many items of expense could then be eliminated that remain more or less constant so long as some steam service has to be kept. The next step forward for this type of power seems to be along that line. A return of traffic density corresponding to that existing in former years would also expand the usefulness of such equipment."

Branch Line Terminal Showing Gas-Electric Car in Service

Mr. H. A. Scandrett, President of the Chicago, Milwaukee, St. Paul and Pacific finds that "The cost of operating these cars is considerably less than steam locomotives," and that "this and lower maintenance makes it possible to serve communities where the traffic density is insufficient to cover the expense of steam trains." He says:

"Our experience demonstrates that it is entirely practicable to substitute gas-electric cars for steam service on branch lines and on main lines where the traffic is comparatively light.

"The cost of operating these cars is considerably less than steam locomotives. The principal differentiating factors are smaller train and engine crews; lesser cost of fuel, lubricants and supplies; reduction in engine house and terminal expense; decrease in maintenance of fuel and water supply plants; lighter track maintenance, and elimination of claims for fires set out along the railroad.

"In the maintenance of gas-electric cars there is a possibility of reduction in expense even greater than in their operation. The cars will make greater mileage between shoppings and require less expense to keep them in condition.

"The lower cost of operating and maintaining gas-electric cars makes it possible to serve communities where the traffic density is insufficient to cover the expense of steam trains.

"Assuming that the manufacturers probably will design gas-electric cars of greater tractive effort, the future should see their adaptation to light way freight or peddler trains, switching service in small terminals, suburban service, inspection trains and light work-train service."

And so it goes. The gas-electric car has won friends everywhere and has made failures nowhere. It is no panacea for all railroad ills, but it is a great tonic for a run-down branch line system.

With this preponderance of expression in favor of the gas-electric car surely there is hope that the white elephant may do the unbelievable—change his color and his temperament and become a real help to the "big show."

A healthy railroad makes a healthy community and stimulates all business and industry. Our nation depends on the railroads.

Why We Have Turned to the Skies

Aerial Transportation an Adjunct to Railway Service

By W. E. Symons

While aerial transportation has been scoffed at by many railroad men, the real student of transportation generally has not only accepted it as a reality, but quietly aided in its development.

In the August, 1927, issue of RAILWAY AND LOCOMOTIVE ENGINEERING there was published an article with a map showing the existing air routes in successful operation in the United States and abroad. Prediction was there made that the United States would in all probability take its place in the development of aerial transportation as it had done in steam railway development.

While the writer did not at that time and does not now set any exact date for the fulfillment of the prophecy, yet, its reaffirmation is made in full confidence of an early realization.

Among the great mass of progressive railroad men there are yet to be found those who point out the decrease in volume of business on our railways in 1927, the decrease in the present year when compared with 1926, and the wonderful increase in the number of busses, trucks, and private automobiles that have taken so much business away from our railways. They ask, "why should we even think of going skyward?"

To those who hold to the above or similar views, we would point out: First—1926 was an abnormal year and should not be used for comparison. Second—The country is so large and is growing so rapidly that even with all our ultra modern means of transportation by rail, water and air, we are hardly up to our requirements.

During the next twenty years there will be a still greater development in trucks and busses and in marine and aerial transportation. But, the steam and electric railways will go right ahead sharing in the general prosperity. The reason for this is simple and plain. All means of transportation will play their part in our continued development as a nation, and with the possible exception of seasonal variations in any particular field, all will be utilized to capacity while some will be overtaxed.

That this feature of growth may be more clearly brought out, the increase in volume of traffic over a period of years on our steam railways is given in the tabulation.

The total tractive power of all locomotives on our steam railways has increased from 839,073,779 lbs. in 1902 to 2,669,341,000 in 1926 or about 218 per cent.

From the foregoing it is evident that we must apply maximum genius and practical engineering skill to the improvement and development of all modern means of transportation.

A combined air and rail passenger service from coast to coast, starting with a Chicago, St. Paul air link, is to be inaugurated. Passengers will fly by day and travel by Pullmans at night thus eliminating the more dangerous territory and periods of the full day. By this schedule thirty-six hours will be cut off the best all-train schedules between New York and Los Angeles or San Francisco.

Year	Railway Mail Revenue	Railway Express Revenue	Railway Freight Revenue	Railway Passenger Revenue
1894	$30,059,657	$23,035,300	$699,000,000	$285,000,000
1899	35,999,011	26,756,054	915,000,000	291,000,000
1904	44,499,732	41,875,636	1,379,002,693	444,000,000
1909	49,380,783	59,647,022	1,677,614,678	564,000,000
1914	54,892,500	75,320,532	2,114,697,629	700,000,000
1919	58,193,615	128,661,431	3,628,404,571	1,192,000,000
1924	98,804,520	144,013,157	4,388,949,789	1,079,000,000
1926	96,996,316	149,733,639	4,856,698,210	1,044,178,622

The above air and rail combination is likely to be followed by an air and steamer combine, whereby, steamers will carry passenger planes that when weather conditions permit will enable passengers to save a half a day or more by flying at either end of their journey should they desire to do so.

When Adam and Eve were in the Garden of Eden there then existed all the natural elements which man has since used in the development of the civilized world. It is not unreasonable to suppose, nor is it rash to prophesy that equally as great if not greater strides will be made in aerial transportation during the next 25 years than were ever made in any 50-year period of steam railway, marine or electric transportation development.

Fuel Conservation

A Paper Presented to the International Railway Fuel Association

By T. W. Evans, Vice-President, Chicago Junction Railway

When a condition is reached such that the saving in the cost of labor and supplies by the revision of grades, installation of improved mechanical appliances and facilities in operating a given property, is enough to more than pay the interest upon the funds which must be invested for such improvements, the funds are invested when they can be obtained and the company pays out less money for interest and operation under the improved condition in performing the same amount of service, than it did under the conditions which existed before the improvements were made. It logically follows that the tendency to displace men with machines and imporvements of this character is accelerated by demands of labor for increased compensation. I sometimes wonder if some of the men so actively pressing for increased wages, fully appreciate the impracticability of having a high wage rate and no job to which it might be applied.

Returning now to our subject, the question arises what can the Engineering Department contribute to fuel economy? In the location of new and the revision of old lines, it should make the most careful studies to obtain a location with the lowest grades, minimum curvature, rise and fall and distance, consistent with the economical or financial restrictions imposed. Other considerations besides fuel economy will influence the decision in the same direction. Passing sidings should be located so that trains can, with full tonnage in either direction, pull in and out of sidings without difficulty. I have observed a good many instances of passing sidings being located on summits, apparently because of the feeling that it would be better to have a siding at such a location where there could be a telegraph office at the town, and without much regard to the feasibility of getting into the siding with a tonnage train from either direction. A siding conveniently located near a telegraph office is, of course, an advantage, but my point is that everything should be taken into consideration before definitely deciding upon the location of a passing track and that, when the location is decided the construction should be such that it can be used economically.

In reconstruction and ordinary maintenance work, the Engineering Department can contribute materially to fuel economy by organizing its work programs so as to make it necessary to have slow orders on track or structures for a minimum length of time, and prescribing such maximum speeds as are consistent with safety. Well maintained track and roadway with curves kept in good line and gauge, and track in good level, line, gauge and surface, and without the necessity for speed restrictions, all have the effect of facilitating the movement of trains and decreasing the coal bill. The treatment of boiler water whenever indicated by scientific methods easily understood by practical men, is also a very important factor in fuel economy. The Engineering Department should also give particular study, as it usually does, to the location of signals. A large number of things have to be taken into consideration, but, in so far as the conditions of the problem will permit, signals should be so located as to contribute to fuel economy, as well as to facility and safety of train movement.

It devolves upon the mechanical department to design efficient locomotives and thereafter maintain them in first class condition from a fuel economy standpoint. Among some of the items requiring mechanical department's co-operation in fuel economy are the following:

(1) Clean tubes.

(2) Tight steam connections and tubes, both water and superheating, as well as tight superheating connections.

(3) Prompt detection and correction of air leaks in front end and on all air operated auxiliary apparatus.

(4) Proper air openings through grates and ashpan.

(5) Efficient maintenance of packing.

(6) Enough lubrication of proper quality.

(7) Efficient maintenance of air brake system on all equipment.

(8) Efficient steam distribution, which requires not only good valve setting, but prompt elimination of lost motion in steam distribution system.

(9) Higher steam pressures whenever possible.

(10) Provision of back pressure gauges.

(11) Fullest practicable utilization of exhaust steam for feed water heating, train heating, etc.

(12) Modern methods for firing up locomotives and reduction to minimum of fuel required to keep locomotives under steam at terminals.

(13) Educate and supervise firemen and roundhouse men in fuel economy.

(14) Rearrange runs and running repair schedules so as to permit locomotives to make runs over two or more locomotive districts whenever practicable.

The transportation department should do the following:

(1) Assign power where the greatest economies will be realized from its use.

(2) As far as practicable load trains in the ruling direction of traffic 100 per cent of the established rating.

(3) As far as practicable dispatch trains from terminals at hours when trains can get over the district with minimum delay by opposing or superior trains.

(4) Whenever possible accumulate tonnage for pick-ups at points where delay will be a minimum.

(5) As far as the nature and volume of the traffic will permit, build up trains at initial terminals so that switching and delay at intermediate terminals will be reduced to a minimum.

(6) Provide sidings at meeting points of sufficient capacity to avoid sawing, or holding trains back to avoid this expensive practice.

(7) Promptly dispatch all trains on the call and, at final terminal, receive trains without delay.

(8) Arrange schedules as far as practicable to reduce number of locomotives kept under steam at outlying points to a minimum.

(9) Arrange schedules as far as practicable to take advantage of favorable grades and give trains more time on sections of the line where grades are unfavorable.

(10) Reduce to a minimum delays in handling locomotives from yard to roundhouse, and vice versa.

The traffic department, strange as it may seem, can be of very great assistance in selling to shippers the idea of heavier car loading and in rate cases before regulating authorities, earnestly advocating increase in carload minima. I know of no effective way for the public to enjoy low rates or, in some instances, avoid increases in rates, than by the increase of carload minima.

The purchasing department plays a very important part in fuel economy—first, in purchasing fuel at equitable prices and of proper quality for efficient use; second, in purchasing it at places where the cost of its distribution to point of delivery to locomotives will be a minimum; and, third, in providing efficient inspection at the mines to insure maintenance of specified quality.

Statistics of the Interstate Commerce Commission for Class I railroads of the United States show that the average gross ton miles per train (including locomotives and tenders) was 1,970 in 1926, as against 1,640 in 1921, or an increase of over 20 per cent, while the net tons per freight train mile increased from 651 in 1921, to 772 in 1926, or 18.6 per cent. In the year 1921 the pounds of fuel consumed per 1,000 gross ton miles (including locomotives and tenders) for Class I railroads of the United States, was 162 as against 137 in 1926, a decrease of 15.43 per cent. The pounds of fuel consumed per passenger train car mile decreased from 17.7 in 1921 to 15.8 in 1926, or 10.73 per cent. Considering the increased weights of both locomotives and passenger train cars in 1926 versus 1921, as well as the higher average speeds maintained, the showing is very creditable.

While, no doubt, due credit should be given to the officers and men directly concerned in supervising, instructing and directing the operation of locomotives, and the enginemen and firemen operating them, we must not overlook the fact that superheaters, feed water heaters, thermic siphons, improved locomotive maintenance, better locomotive design, faster train movement and better train loading, to mention only a few of the elements, are each and all entitled to a share of the credit for the results obtained.

If we assume that 20 per cent of the total fuel consumption represents cost of firing up locomotives preparing for the trip, radiation losses, standby losses when meeting or clearing trains, and similar items, leaving the remaining 80 per cent to be distributed over the ton miles made by the train, it is obvious that the fuel consumption per 1,000 gross ton miles will decrease as the tons per train increase, because of the assumed constant 20 per cent being spread over the greater number of tons.

I have sometimes been asked what has been the greatest single contributing factor in bringing about improvements in fuel economy. Other things being equal, I think it fairly may be attributed to changes in operating organization which have, in one way or another, established an independent check upon mechanical department activities.

When the mechanical department had sole authority over and responsibility for locomotive operation, with no independent check upon it, there existed the possibility that locomotives might be dispatched from the terminal in imperfect condition, when considered from the standpoint of fuel economy, either without the knowledge of the responsible mechanical officer, or without a just appreciation of the effect which this condition would have upon economy. Moreover, the responsibilities of mechanical officers were many and varied and naturally they occupied themselves with what appeared to them to be the more important problems of locomotive maintenance and operation.

When this condition became apparent, a good many years ago, some of the lines transferred the traveling engineers or a road foreman of engines from the mechanical to the transportation department. Others created the office of fuel supervisor or its equivalent, reporting directly to the general manager or some other operating officer independent of the mechanical department. As time passed, changes in organization of this character became general. The beneficial effects of these changes are almost universally admitted. At first there was more or less controversy, as is inevitable when changes in organization are made, but I believe now a majority of the mechanical officers approve the change, as it provides a check upon the efficiency of their various subordinates and assists them in obtaining from the management sufficient appropriations for the efficient maintenance and handling of the power.

New 4-6-2 Type Locomotives of the Bangor & Aroostook Railroad

They Replace Saturated Steam Locomotives of the 4-6-0 Type

The American Locomotive Company has recently delivered five passenger locomotives of the 4-6-2 type to the Bangor & Aroostook Railroad. These locomotives average 237 miles each day, running between Bangor, Maine, and Van Buren. The maximum grades and curves on this line are 1.2 per cent and 8 deg. respectively. The locomotives replace five 4-6-0 type saturated steam locomotives, which are now used in lighter service.

The total weight of the locomotive loaded is 237,000 lb., of which 141,000 lb. is on the drives. The total weight, including the tender, is 398,000 lb. Using 210 lb. boiler pressure, with 21-in. by 28-in. cylinders and 69-in. driving wheels, these locomotives develop a tractive force of 32,000 lb. The steam distribution is controlled by piston valves 12-in. in diameter, actuated by the Baker type of valve gear, producing a travel of 7½ in. An Alco power reverse gear is employed.

The boiler is of the extended wagon top design. The first course is straight and has an inside diameter of 67 in., while the second course is tapered, and the third course, on which a one-piece pressed-steed dome is located, is straight and has an inside diameter of 73 in. The firebox dimensions, which are the largest on the road, are 102 in. by 73¼ in., giving a grate area of 52 sq. ft. The firebox is equipped with two Thermic syphons and two arch tubes. A type A superheater with 30 units is used. A total of 550 flexible staybolts are used in the firebox. Each engine is equipped with a soot blower, a pyrometer and a back pressure gage. The Chamber front end throttle is used, and Flexite steam pipe castings are used at the smoke box points.

In a effort to eliminate knuckle pins as a source of trouble and to reduce maintenance, a new scheme of rod connections has been applied to three engines. Instead of using knuckle pins, the back end of the main rod and the two intermediate ends of the side rods fit over the main pin. These side rods are equipped with floating bushings on the main pin, each rod end having its own bushing. At the top of the rod drawing the rods are shown connected up in this fashion for an eight-coupled locomotive. An advantage of this method of rod connection is that if one side rod fails, the main rod is able to drive two pairs of drivers from the main pin, instead of one pair. Under the conventional type of rod connection, a knuckle pin or rod failure means the loss of the service of two pairs of drivers.

Floating bushings with six rows of ¼-in. holes, nine holes in each row, alternating spaced, are used on the back end of the main rod. These bushings float in gun iron outer bushings pressed in the rod. Grooves ⅜ in. by ⅛ in. are cut in the outer bushing for distribution of the grease to the floating bushing. The holes in the floating bushings are countersunk ¼ in. deep for the purpose of more readily feeding the grease to the pins. This type of rod connection and floating bushing has caused no trouble during 30,000 miles of service.

The locomotives are equipped with the Blunt engine and troiler trucks, supplied with Hennessy lubricators. Briefly, the principal features in the design of these trucks are the elimination of bolt fastening and equalizers, elimination of wearing surfaces on the pedestals, two part hub liners and a centering device which permits a swing of 2¾ in. each side of the center. The wheel base of 86 in. permits the use of long flexible, straight leave easy riding springs. Hinged lids on the trailer trucks are provided at the ends of the journal box castings which permit the packing and lubricating of cellars without necessitating their removal.

4-6-2 Type Locomotive of the Bangor & Aroostook Railroad, Built by the American Locomotive Company

Principal Details of Bangor & Aroostook 4-6-2 Type Locomotives

Railroad	Bangor & Aroostook
Type of locomotive	4-6-2
Service	Passenger
Cylinders, diameter and stroke	21 in. by 28 in.
Valve gear, type	Baker
Valves, piston type, size	12 in.
Maximum travel	7½ in.
Outside lap	1¼ in.
Exhaust clearance	⅛ in.
Lead in full gear	¼ in.
Cut-off in full gear, per cent	85
Weights in working order:	
On drivers	141,000 lb.
On front truck	49,500 lb.
On trailing truck	46,500 lb
Engine	237,000 lb.
Tender	161,000 lb.
Total engine and tender	398,000 lb.
Wheel bases:	
Driving	12 ft. 6 in.
Rigid	12 ft. 6 in.
Total engine	33 ft. 4 in.
Total engine and tender	64 ft. 5½ in.
Wheels, diameter outside tires:	
Driving	69 in.
Front truck	31 in.
Trailing truck	43 in.
Journals, diameter and length:	
Driving, main	10 in. by 12 in.
Driving, others	9 in. by 12 in.
Front truck	6½ in. by 12 in.
Trailing truck	8 in. by 14 in.
Boiler:	
Type	Extended wagon top
Steam pressure	210 lbs.
Fuel, kind	Bituminous
Diameter, first ring, inside	67 in.
Firebox, length and width	102 in. by 73¼ in.
Height, mud ring to crown sheet, front	74 in.
Height, mud ring to crown sheet, back	47 in.
Arch tubes, number	2
Tubes, number and diameter	166—2 in.
Flues, number and diameter	30—5⅜ in.
Length over tube sheets	19 ft.
Tube spacing	¾ in.
Grate area	52 sq. ft.
Heating surface:	
Firebox and comb. chamber	168 sq. ft.
Arch tubes and syphons	62 sq. ft.
Tubes	1,643 sq. ft.
Flues	798 sq. ft.
Total evaporative	2,671 sq. ft.
Superheating	693 sq. ft.
Comb. evaporative and superheating	3,364 sq. ft.
Tender:	
Style	Acme tank
Water capacity	8,500 gals.
Fuel capacity	12 tons
Rated tractive force, 85 per cent	32,000 lb.

The tender is carried on a Commonwealth one-piece cast steel tender frame. The principal dimensions and weights are given in the accompanying table.

Railways to Acquire Express Business

A plan has been prepared for the acquisition of the American Railway Express Company and the constitution of a new company to be called "Railway Express Agency, Inc.," to be owned by the railroads in proportion to their shares in the total railway express business.

The plan has grown out of dissatisfaction among railroads as to the terms of the contracts between the roads and the American Railway Express Company as renewed in 1923 and which expire next February.

The railway executives have voted not to renew the contracts, and a committee has been appointed to draft plans to take over the express business. This committee is composed of W. B. Storey, chairman; Gen. W. W. Atterbury, president of the Pennsylvania; P. E. Crowley, president of the New York Central; Charles Donnelly, president of the Northern Pacific; L. A. Downs, president of the Illinois Central; Carl R. Gray, president of the Union Pacific; E. J. Pearson, president of the New Haven; and Bird M. Robinson, president of the American Short Lines Railroad Association, representing 375 small roads.

The carriers contend that losses of between $55,000,000 and $60,000,000 have resulted from the contracts as they now stand, while the express company is described as actually receiving about 7 per cent.

The attitude of the carriers is understood to be that the express company, with a small investment, occupies a dominant position in the conduct of a business which is handled by roads with large investments in property. In the second place, it is pointed out in railroad circles, contracts with the express company have made it impossible for the railroads to discuss with the Commerce Commission rates pertaining to express shipments.

It was felt that this situation was entirely one-sided and unjustified. All roads with the exception of the Southern Railway, which handles its own express business, are described as having been unanimous in rejecting a renewal of the contracts with the express company.

The plan asks the railroads to approve the appointment of four agents, with authority defined under the plan, to negotiate with the express company for acquisition of its property or capital stock and to represent the carriers in other matters pertaining to the plan.

A 660-Hp., 87-Ton Oil-Electric Switcher for the Long Island Railroad

By J. H. Harvey, Railway Equipment Engineering Dept.
Westinghouse Electric and Manufacturing Company

The new 660-hp., 87-ton, Baldwin-Westinghouse, oil-electric switcher locomotive for the Long Island Railroad has many features which are unique. The locomotive consists of two units each complete with oil engine, generator, motors, control and auxiliary equipment. The two units are coupled together for normal multiple operation. Simultaneous control of the oil engine speeds and electrical connections on both units is effected by means of a single control lever on the master controller. Automatic operation of the control and auxiliary equipment has been incorporated wherever possible, thus relieving the engineman of the distracting influences present in other designs, and insuring proper and efficient operation of the equipment under all conditions of locomotive speed and amount of trailing load.

The mechanical parts were built by the Baldwin Locomotive Works. Particular attention was given to providing a light weight yet sturdy frame and cab structure. Each unit has two axles, giving a locomotive wheel arrangement of B + B and permitting the total locomotive weight to be utilized in obtaining tractive effort. Principal dimensions are:

Rigid wheel base	114 in.
Length of cab	20 ft., 0 in.
Total length of locomotive between couplers	46 ft., 8½ in.
Width overall	10 ft., 1½ in.
Height overall	14 ft., 11 in.

For initial operation the two units, coupled together by means of a drawbar, will be operated in multiple. This drawbar may be removed, however, and MCB couplers mounted in its place, thus making two independent operating units.

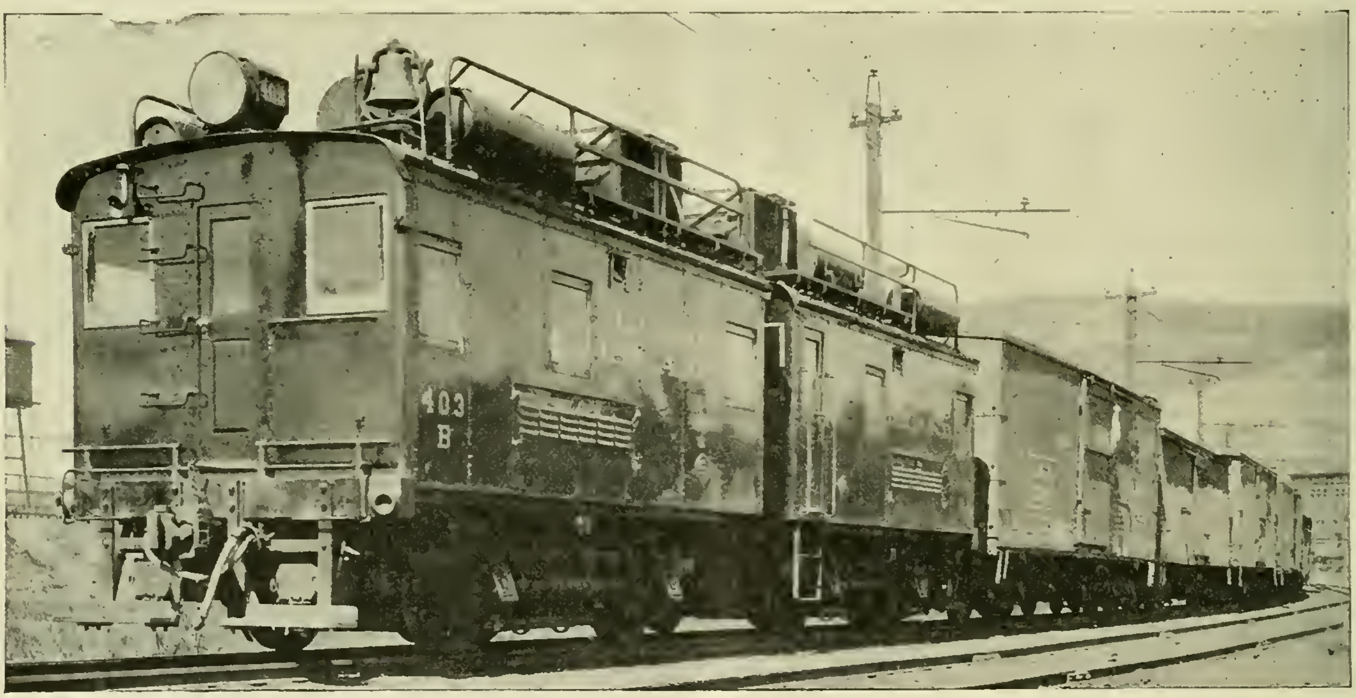
The cab equipment layout is such that an additional controller and brake pedestal may be added to provide double end control in case single unit operation is desired.

The engineman's station in the leading end of each unit is separated from the engine and equipment compartment by means of a bulkhead. Doors at each side and a removable sheet in the center have been placed in this bulkhead. There is an aisle space along each side of the units which permit access to all parts of the apparatus in the cab.

Oil Engine

The Westinghouse-Beardmore oil engine was built at the South Philadelphia Works of the Westinghouse Electric & Manufacturing Company. It is a light-weight, high-speed, vertical, six cylinder engine using solid injection and operating on a four stroke cycle. It has a speed range of from 300 to 800 r.p.m. and develops 330 hp. at the higher speed.

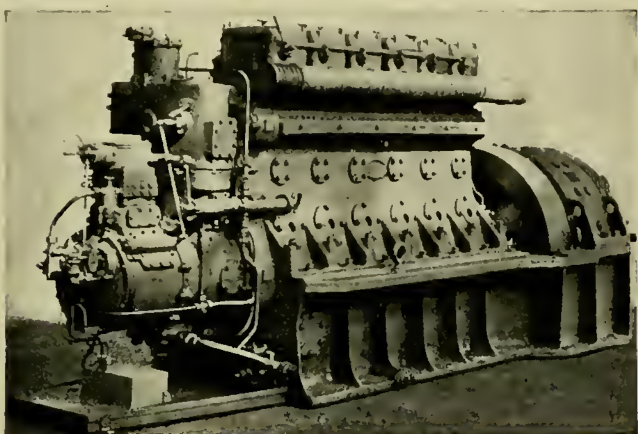
The engine is the result of two and one-half years' experience in the field, having been operated in high speed motor car service for approximately one million miles. The desirability of a light-weight, high-speed Diesel engine for locomotive and rail car application has long been recognized. The Westinghouse-Beardmore oil engine, including flywheel, weighs approximately 7,000 lb., or 21.2 lb. per bhp. This low weight allows a total locomotive weight of about 87 tons, which is sufficient for adhesion purposes in the service intended. Any excess of weight beyond this will only serve to reduce the effective drawbar pull of the locomotive unit, which in turn means a



Oil-Electric Locomotive and Train on Test Track at East Pittsburgh, Pa.

reduction in useful load which the locomotive can haul at a maximum speed. Naturally, reduced weight and size of the oil engine means a corresponding reduction in weight of the transmission gear, mechanical parts, and cab structure.

The oil engine is a compact, well proportioned, and rugged piece of apparatus, and light weight is obtained through the proper selection of materials and careful design along stress lines. Features of this engine, besides its light weight, are economy, smoothness of operation obtained by a large crankshaft and careful balancing of parts; accessibility for maintenance; and neatness of appearance, the exterior being almost free from fixtures which are susceptible to damage. The fuel, lubricating oil, and cooling water pumps are integral with the engine proper.



Intake Side of Westinghouse-Beardmore 330-hp. Oil Engine and Generator Unit

This engine is placed longitudinally in the center of the equipment compartment on a cast steel bedplate which is bolted to the cab underframe. The bedplate provides unit support for the engine and generator, and in addition contains the lubricating oil sump.

Main and Auxiliary Generators

Bolted to the engine flywheel is the generating unit consisting of a Westinghouse direct-current, 660-volt, main generator and a Westinghouse direct-current, 64-volt, auxiliary generator. One bearing only is used at the commutator end of the main generator, the other end being carried by the engine main bearing. The rotor of the auxiliary generator is pressed on the main generator shaft extension. Its stator is bolted to the bracket of the main generator and may be readily removed without disturbing the main generator.

The main generator is used, first, for starting the oil engine, obtaining power from a 64-volt, 272 ampere-hour storage battery; second, for charging the battery and operating the compressors at the engine idling speed of 300 r.p.m.; and third, for supplying power to the traction motors at higher engine speeds.

The auxiliary generator furnishes power for compressor operation, main generator field excitation and battery charging while the main generator is running above idling speed.

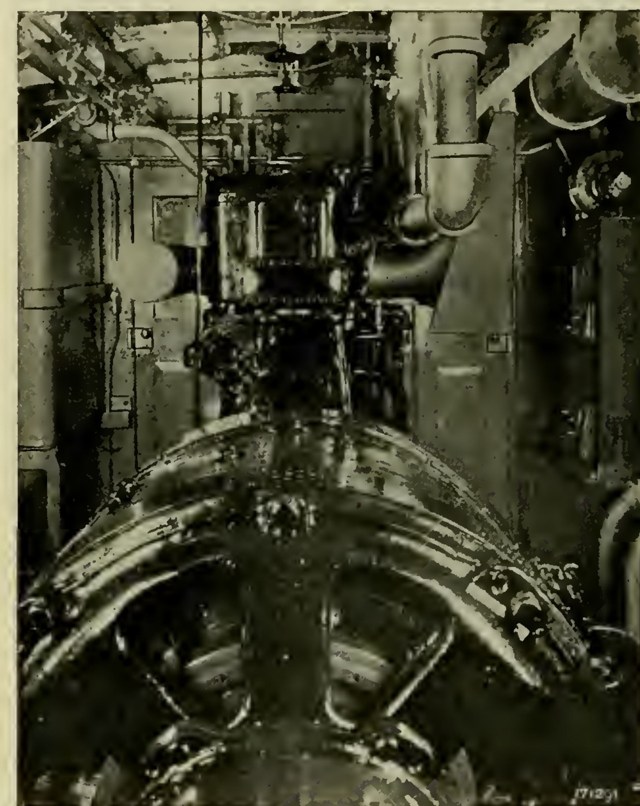
Traction Motors

Each unit is equipped with two Westinghouse type 308-H motors having a one-hour rating of 306 amperes at 600 volts and a continuous rating of 140 amperes at 300 volts. This motor is totally enclosed.

A maximum locomotive speed of 30 miles an hour is attained by the use of the 16:66 gear ratio and 38-inch wheels. The maximum tractive effort of the locomotive is 49,500 lb.

Air Brake Equipment

Westinghouse No. 14 EL air brake equipment is used on the locomotive. Brake pipe, main reservoir pipe, and equalizing pipe connections are carried between cabs thus giving complete control of locomotive and train brakes from either unit. Two DH-20 compressors are mounted on the underframe at the No. 1 end of each unit. These compressors are wound for 64 volts and operate from the main or auxiliary generators as explained above or from the battery when the engine is shut down. This switching of compressor connections is entirely automatic, thus assuring a full air supply at all times.



Interior of Locomotive Cab From No. 2 End

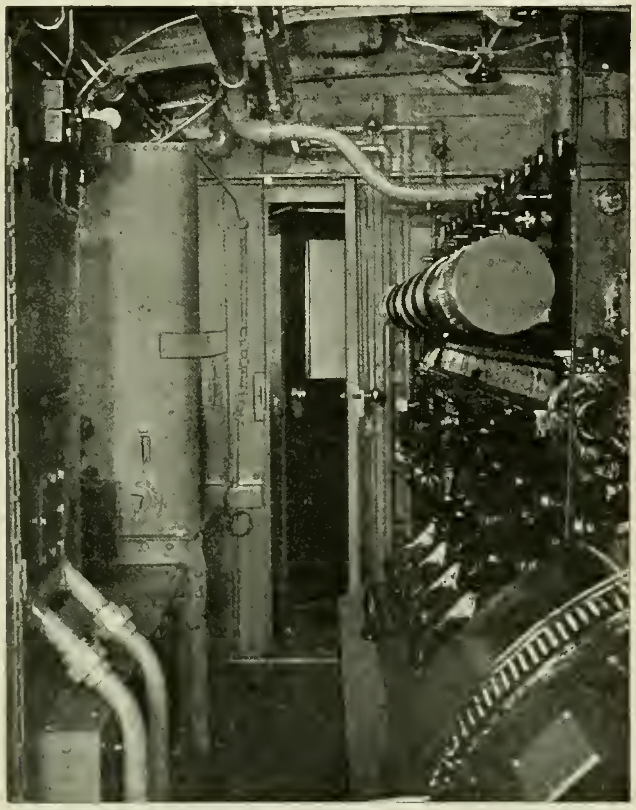
Control Apparatus

The motor reversers, all unit switches, magnetic contactors, battery cutout, motor cutout, and cab cutout switches, lighting, compressor and blower switches and fuses, generator field resistors and torque governor comprising the control apparatus of each unit, are contained in two steel cabinets placed along one side of each cab.

The engine starting controller is mounted toward the front of the engine compartment at a point convenient for one-man operation of the control lever, fuel trip and decompression valves during the starting period. This controller connects the main generator to the storage battery and accelerates the engine to firing speed in successive steps in order to minimize the starting duty of the battery.

The master controller mounted in the operating compartment at the engineman's station has two levers only, the reverse drum and the power drum handles. The customary mechanical interlocking between these drums to prevent operating the reverser when power is applied to the traction motors has been incorporated.

Operation of the locomotive from the master controller is similar to the operation of ordinary electric locomotive equipment. With the controller in the "off" position all control switches are open and the engine rotates at 300 r.p.m. or idling speed. The next or "idle" position connects the battery to the main generator for charging at this same engine speed. To start the locomotive the control lever is notched out from the "idle" position to the first running notch. This movement connects the traction motors to the main generator at low engine speed. Notching out to each successive position on the power drum increases the oil-engine speed which in turn increases the main generator voltage impressed on the traction motors. The locomotive acceleration is thus under complete control of one power drum lever. In notching back to stop the locomotive a mechanical interlock is employed to prevent overrunning the "idle" or battery charging position. This interlock must be operated by means of a push button mounted on the top of the controller whenever the control lever is thrown from "idle" to "off." Inadvertent loss of battery charge as the locomotive is at standstill is thus prevented.



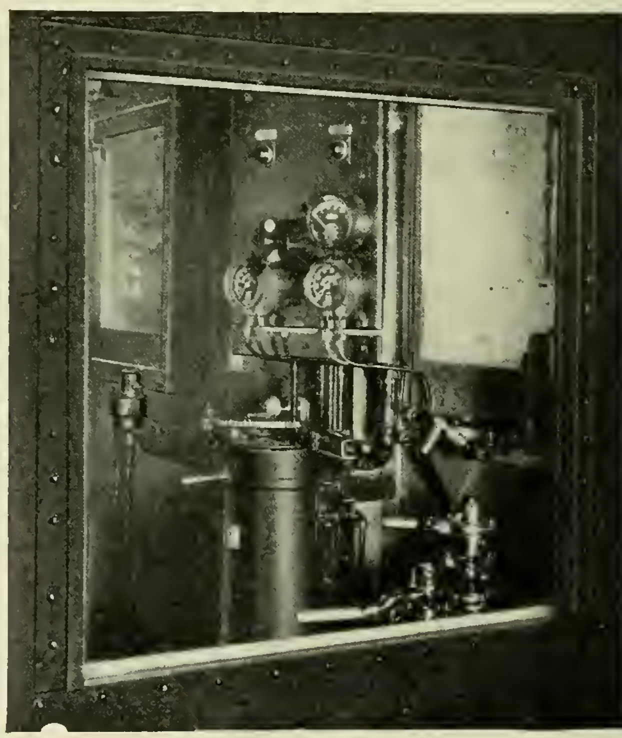
Left Hand Aisle Looking Toward No. 1 End of Locomotive

Multiple operation of the two oil engines is effected by means of a pneumatic piston incorporated in the engine speed governor. The governor position, and hence engine speed, is a function of the air pressure applied upon the piston. A governor control air line connecting the two governor air chambers in parallel is carried between the two units.

The necessary variation in air pressure is produced by a reducing valve, the setting of which is determined by the angular displacement of the control lever of the master controller. All necessary control air line cutouts are actuated by movement of the reverse drum lever. No additional operations on the part of the engineman while he is changing ends have therefore been added. This reducing valve is mounted on the base of the electrical control portion of the master controller thus making an integral control unit the parts of which, nevertheless, are easily accessible.

As the action of this system is based essentially upon a variation in air pressure, the leakage being negligible, the control is extremely sensitive and exact. Since the engine speed rises directly with the air pressure, an accidental parting of the coupling between units would serve to drop the speed of each engine to "idle" owing to loss of air pressure in the control line.

The torque governor may be termed the "heart of the control system." It is a relay having a saturation characteristic identical with that of the main generator and carrying two sets of windings. The main generator field current passes through one set and the other one receives a current proportional to the main generator armature current. The magnetic force produced by these windings is therefore proportional to the torque acting upon the main generator shaft. A spring restrains motion of the relay contacts until a torque of predetermined value is exceeded at which point the relay operates to open its contact points. This, in turn, drops out a magnetic contactor to insert a section of resistance in the main generator field circuit, thus lowering the voltage and consequently the load delivered by the main generator. As the moving parts of these relays have a small mass and as the increment of field resistance added is comparatively large, the movement of the relays when in action is quite rapid. The generator voltage is thus automatically maintained at such a value as will load the oil engine to its rated capacity and prevent overloading. It positively insures against the possibility of stalling the oil engine and permits the engineman to notch out to the last position in order to obtain full engine horsepower when moving a heavy load at low locomotive speeds.



Control Station on Locomotive Showing Master Controller, Brake Valve Pedestal and Meter Panel

The torque governor, in addition to the above features makes possible an automatic transition of the motor connections from series to parallel. In order to obtain the benefit of maximum locomotive speed at large values of tractive effort the motors are connected in series as the locomotive is started. Further movement of the control lever then sets up the parallel motor connection control circuit. The completion of this control circuit is governed by the action of a current limit relay which drops when the tractive effort falls off to its proper value. The transition is thus made without loss of locomotive speed and tractive effort. The operation of the torque governor so softens the power surge, which would otherwise be set up, that the point at which the transition takes place is difficult to determine unless the generator ammeter is observed closely.

The meter and gauge panel mounted in the engineman's compartment is equipped with two indicator lamps in addition to the main generator ammeter and air brake gauges. These lamps show, by the intensity of light emitted, the rapidity of the torque governor operation and give the engineman a check on the operation of each oil engine and the load division between units.

Two emergency engine stop push-switches are mounted near the master controller directly under the light and compressor control switches. These switches enable the engineman to stop either oil engine from his position in the cab. Operation of these switches trips the overspeed governor on the oil engine and by-passes the fuel oil from the injection nozzles thereby causing the firing of the engine to cease immediately.

Mounted on the bulkhead in full view of the engineman are the fuel oil and water gauges. The latter combines the two features of showing the amount of cooling water in the tanks when the engine is stopped and indicating water flow through the cooling system.

Excessive temperature of the cooling water is indicated by the operation of a pneumatic whistle placed in the engineman's compartment.

The possibility of dangerously low pressure of lubricating oil to the bearings is prevented by a pressure switch which also operates the above signal whistle when the danger zone is reached. This signal operates in both units in case of failures on either.

Sanding of the rail in the direction of locomotive travel is insured by the use of one sander push-switch only. The electrical connections from this switch to the electro-pneumatic sander valves are carried through the reverse drum of the master controller so that the selection of the proper sanders is automatic.

Fuel Tanks and Cooling System

Each unit has one fuel oil tank mounted on the left hand side of No. 1 end and one on the right hand side of No. 2 end in the engine compartment. These tanks are connected by a common supply line to the oil engine. The fuel oil capacity is 210 gallons per unit or 420 gallons for the total locomotive.

Suspended from the roof directly above the right hand aisle is the tank containing the engine cooling water. This location was chosen to insure a full head of cooling water in the engine jacket under all conditions. In addition to this feature the tank design permits an advantageous disposal of the piping to and from the engine jacket. The floor along the aisles is free from cross piping.

Positive cooling of the water and lubricating oil is insured by forced ventilation of the radiators which are placed on the clerestory hatch at No. 2 end of each unit. The blower motor is of weatherproof construction with a shaft extension on each end for accommodating two propeller type fans. Operation of the blower motor is under the control of a thermostat which starts the blowers when the upper limit of water temperature is reached. The design provides for overcooling so that the temperature falls to the point at which the blowers cut out. In this manner the cooling water is kept at the proper temperature for maximum engine efficiency. The radiators are mounted directly in front of the fans, the oil cooler to the left and the water cooler to the right of the blower motor. They are self-draining when the engine is shut down thus preventing freezing of the water system in winter.

As the cooling system is placed directly over the generators, the hatch has been made in two parts, one portion covering the engine and the other, on which the radiating unit is placed, covering the generators. It is thus possible to remove either the engine or the generators from the unit by simply uncovering the corresponding section of the clerestory leaving the other section intact. Removal of both portions of the hatch permits the complete power plant consisting of engine, bedplate and generators to be taken out as a unit.

It should be noted that the complete removal of the power plant unit, though simple, is desirable or necessary only when complete overhauling or major repairs are to be made on the equipment. The free space surrounding the engine is sufficient to permit inspections and minor repairs with ease.

This is the first application of the Westinghouse-Beardmore engine and torque governor control to switcher locomotive duty, and data gathered from tests and from preliminary service indicate that its operation will be as satisfactory as similar equipments now operating in high-speed passenger car service.

Rock Island Oil-Burning Locomotives

The Chicago, Rock Island & Pacific plans to substitute oil-burning locomotives for coal-burning locomotives on more than 1,500 miles of lines in Kansas, Texas and Oklahoma, including the entire El Paso-Amarillo division, the conversion to be completed by October 15 for both freight and passenger service. The conversion of this section of the road will give the Rock Island a total of 2,700 miles of lines on which oil will be used instead of coal or approximately one-third of the entire system. Oil is now used in locomotives on the lines in Arkansas and Louisiana and on the main line between Caldwell, Kan., and Dallas, Tex. To supply the 125 locomotives used in the territory referred to the railway will erect road-side oil stations at Herington, Kan., Hutchinson, Pratt, Liberal and Bucklin; Dalhart, Tex., McLean and Amarillo; Sayre, Okla., Clinton Junction, Geary and Ingersoll and Tucumari, N. M. A contract has been made with the Phillips Petroleum Company for the necessary fuel oil.

Five New Records in Freight Service

New records since 1920 were made by the Class I steam railways in the first five months this year in five out of ten selected items of freight service operating averages, according to the Bureau of Statistics of the Interstate Commerce Commission.

The following new records were reported: gross train-load (excluding locomotives), 1,787 tons; gross ton-miles per train-hour (excluding locomotives), 22,956; car miles per car-day, 29.9; number of cars per train (including caboose), 47.2; pounds of coal per 1,000 gross ton-miles (including locomotive), 134.

In the following five items, better records were made for the five-month period in individual years previous to 1928: net ton-miles per mile of road per day; net train-load; net ton-miles per car-day; average carload; and per cent of loaded cars to total.

For the month of May, 1928, records were made in precisely the same items as were reported for the five month period.

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Changes in Public Taste Affect Rail Traffic

The tastes, habits and mode of living of the American people have changed greatly within recent years, and all these changes are reflected in railway freight business, it is revealed in a summary of traffic statistics just made available by the Interstate Commerce Commission.

Dividing the 28-year period from 1899 to 1927 into four periods of seven years each, it becomes apparent that any changes in freight business that have occurred have been due only in small measure to changes in the rate of growth of population. The smallest increase of population during these periods was 10 per cent and the largest only 15 per cent. On the other hand, in the seven-year period ending with 1906 the number of tons carried one mile increased 75 per cent; in the period ending with 1913 the increase was 38 per cent; in the period ending with 1920 the advance was again 38 per cent, and in the seven years ending with 1927 it was 5 per cent. The increase between 1920 and 1926 was 8 per cent.

Of particular significance are the figures covering "tonnage originated," because they are not affected by changes in the distance freight is hauled, and therefore throw more light on the amount of commodities of the various kinds that the people are producing, consuming and shipping by rail. In the seven years ending with 1906 the tonnage originated on the railways increased 85.6 per cent; in the seven years ending with 1913, the increase was 28.3 per cent; in the seven years ending with 1920, it was 19.3 per cent, and in the seven years ending with 1927, it was 2.1 per cent.

No classification of commodities can remain standard for many years, because of the number of new commodities brought into production, especially in a country like the United States in which rapid changes are constantly occurring. The influence of the motor vehicle, for example, is easily traceable in the Commission's figures. To it is due relatively the largest increase in tonnage shown during the last fourteen years, namely that of 398 per cent in petroleum and oils. Undoubtedly the motor vehicle was also largely responsible for the increase of 83 per cent in the tonnage of stone, sand and other similar articles, which have been used largely in highway construction.

The decreases in railroad tonnage are equally significant. The use of the horse has greatly dwindled within the last fourteen years, and there was a reduction of 35 per cent in shipments of hay. A reduction of 38 per cent in the tonnage of household goods and furniture originated is doubtless a reflex of the tendency of urban population to increase faster than rural, and for families living in cities to reduce the number of rooms occupied in order to obtain other luxuries.

In the fourteen-year period ending with 1913, the tonnage of manufactured commodities increased less in proportion than that of minerals, and only slightly more in proportion than that of farm products. On the other hand, in the corresponding period ending with 1927 manufactured commodities increased approximately four times as much in proportion as that of farm products, almost twice as much as products of mines and more than six times as much in proportion as that of products of forests.

In other words, there is a marked continuation of the tendency of the American public to increase its consumption of luxuries more in proportion than its consumption of necessities.

Aerial Transportation

The development in aerial transport will serve to relieve railways facilities now employed in mail, express and passenger service and to some extent freight service as is indicated in the article in the present issue on "Why We Have Turned to the Skies."

It will be noted that the total income from the four classes of service referred to above was in 1894, $1,037,094,957, while in 1926 it was $6,147,606,787, an increase of about 481 per cent.

If the increase in population, commerce and industry of this country should be no greater in the next ten years than it has been in the past decade, the character of the service required, due to changed conditions of life will be such that aerial transportation lines will in all reasonable probability be called upon to handle a volume of business easily reaching if not in excess of $600,000,000 annually.

Aside from and in addition to the commercial aspects, the proper development of aerial navigation is a necessity to national defense, the potential value of which cannot be set up in figures.

No one in the steam railway business need fear that aerial transportation will crowd them out, nor owners of railway securities fear its effect on the value of such investments. Those who doubt the value of aerial transport as an important and essential means of transportation or attempt to impede its progress had better get out of the transportation business for if they don't they will surely be forced out.

Locomotive Boiler Corrosion

Bad water has been a problem of railways since the beginning of their operation by locomotives. Notwithstanding the fact that great strides have been made in the improvement of boiler waters through a variety of methods that have been and are now employed, it is still an important and expensive feature of locomotive operation. Credit is due not only the railway officers but others who have specialized in the devising means for the treatment of waters for locomotive boilers which have greatly improved operating conditions.

In the northwest particularly, bad water has imposed a heavy burden on railway officers in that section and while there has been a diversity of opinion as to the value of the formulaes, machines, the chemicals and the methods employed, it must be admitted that if the railways had not given the matter attention until the doctors had all agreed, the bad water problem would never be improved.

The Chicago, Milwaukee & St. Paul has spent much time, energy and money on the water problem. Many valuable contributions have been made to the technical press by C. H. Koyl, engineer of water service of the road, and one of his recent reports will be found elsewhere in these pages.

There is a feature in Mr. Koyl's paper to which we would direct attention and that is his quotation dealing with results secured, not by himself on the St. Paul, but on another line in a bad water country.

It is a time honored policy of this publication to hold aloof from unsettled or contraversial questions involving locomotive design, operation or maintenance and particularly where such issues may give rise to even the faintest suspicion that we would lend our voice to commercialization in such matters.

However, it would seem that any system of water treatment that will extend the life of boiler tubes from two and three to as much as ten or twelve years should be given most respectful consideration by all those interested in the subject, regardless of whose device, formulae or method of treatment it may be.

There must be available with those who are successfully treating boiler waters a vast amount of unpublished data on the subject. We cordially invite contributions on this important subject which to many is still a very perplexing one.

Conference on Weights and Measures

A most interesting and noteworthy incident of the annual meeting of the National Conference on Weights and Measures held during the week of May 21st, at Washington, D. C., was the declaration of Dr. Burgess, Director of the Bureau of Standards and President of the Conference that the Bureau "is not working for the compulsory adoption of the metric system."

It is to be hoped that Dr. Burgess will go a step further and amplify the foregoing statement with a further declaration that the Bureau will neither advocate, foster or lend aid to any plan that might tend to interfere with the continued adherence to the established customs of the industrial life of the American people, and further, that the Bureau will at all times hold itself ready to serve the individual, corporation, firm or society in accordance with the provisions of the law under which the Bureau was created.

The action of the American Institute of Weights and Measures with respect to the Tilson Bill, which it was believed was intended to give the Bureau of Standards control over all measuring devices and indirectly result in compulsory adoption of the metric system was criticized by Dr. Burgess. In replying to his criticism, Mr. Bullock, Secretary of the Institute of Weights and Measures stated:

"In the opinion of the American Institute of Weights and Measures, the Tilson Bill, H. R. 7208, specifies that weighing and measuring operations shall be performed in terms of standard units, but the bill evades the question of which are the standard units, the customary units or the metric units. The Bureau of Standards, in all its publications states the meter and the kilogram are the fundamental units, although it has no constitutional or congressional authority to do so."

"With respect to the question of the Tilson Bill, H. R. 7208, and the powers it confers on the Bureau of Standards, as against the authorities of the States, the American Institute of Weights and Measures claims that the questions raised by Director Burgess and the Bureau of Standards are all premature because no act of any State Legislature has asked the Federal Government for this particular legislation, and the State and local weights and measures officials who come to Washington every year to discuss it have none of them any authority from the States they come from."

Throughout all this controversy relative to the use of the metric system there appears to us an almost unaccountable attitude on the part of some of the leaders in the scientific and educational fields who endorse the metric system for general adoption. It is obvious that such men know little or nothing of our general industrial problems or how best to solve them. Yet, this insignificant minority are seeking to legislate and dominate the great majority who are the backbone of the country and who in the final analysis furnish the funds that support the educational institutions.

We have in this country over 41,000,000 people engaged in gainful occupations. An overwhelming majority of these workers use our English units of weights and measures and very few employ the metric system. The use of the metric system was legalized in this country in 1866 and is therefore available for use of those who want to use it. Still, we hear from certain quarters a clamor to enforce upon the people something they obviously do not want.

It is to be hoped, therefore, that those who have given aid or support to the fallacious theory that American industry is not entirely competent to shape its own course in such matters will refrain from attempting to dictate to the vast majority in matters which the minority are, as a general rule, not well qualified to pass upon.

National Standards for Pressure Gages

Because the safety of human life often depends upon the accuracy of the pressure gage on a steam boiler or other pressure equipment which can explode, the American Engineering Standards Committee has been asked by the American Society of Mechanical Engineers to approve the establishment of national standards for pressure gages. The standards might provide, for example, for such construction that the gage could not indicate a zero pressure when there is actually sufficient pressure to constitute a grave hazard if a workman should open a boiler or tank—a cause of loss of life in the past. Standardization of vacuum gages is also requested.

Grant of the request by the Standards Committee will be followed by the formation of a committee of technical experts to undertake the work of gage standardization. Besides decreasing the accident hazard, it is expected that the work will benefit manufacturers and purchasers of gages by replacing the great number of sizes and types now being manufactured by a comparatively small number of standardard sizes and types based upon the findings of the committee of technical experts.

The United States Navy Department has done much important work in establishing gage standards for the use of the Navy, and several private concerns, such as the Firestone Tire and Rubber Company, the General Electric Company, and the Pennsylvania Railroad Company have established specifications for their own use. It is expected that these and other specifications will be studied and coordinated in a national way.

The standardization of pressure and vacuum gages may include, in addition to the specifications for accuracy and temperature of calibration, such items as ratings of capacity, arrangement of graduations, numerals, indicator hand, and certain features of the interior mechanism; and the position of stop pins. Establishment of standards for test equipment and standard methods for testing gages have also been recommended to the American Engineering Standards Committee.

Machine Shop Accidents

The popular conception that the buzzing wheels, whirring machinery, and clanking hammers of machine shops offer an extraordinary hazard to human limbs and life appears to be set aside by figures compiled by the Industrial Bureau of the Merchants' Association in connection with an accident prevention contest it is now conducting among 102 metal manufacturers.

A study of the returns from the incomplete metal manufacturers' contest would make it appear that a workman is safer in a machine shop than he is in a bake shop, and that moving objects offer far less hazard when the power behind them is electricity or steam, than they do when propelled by human hands.

One thing that stands out in the returns from all of these contests is that "butter-fingers" are playing a bigger part in the injury of workmen than buzzing saws or any other objects mechanically controlled. The human equation is still the big factor which must be controlled if accidents are to be prevented.

In the machine shops, for instance, the workmen were naturally subjected at times to flying particles. They were handling motor vehicles, power presses, power shears, buzz saws, buffing machinery, milling machinery, grinding machinery, lathes and automatic hammers. Yet, out of a total of 148 lost time accidents sustained by the workmen of these shops fifty-two of them were caused by falling objects or the handling of material. Approximately twenty per cent of the machine shop accidents were attributed to the latter cause alone. Machines figured in approximately 25 per cent of the accidents. This means that the workmen of these plants were in more danger from the objects which they were holding in their hands or moving from one place to another than they were from any of the numerous automatically controlled machines with which they had to deal. There were more breaks in human nerves than there were in steel wheels.

A Precision Value for the Inch

During the past few years considerable effort has been expended by a certain class of our people, that have an overabundance of theories but lack ability or art when it comes to the practical part of things, to make compulsory by congressional action the use of the Metric system of weights and measures in this country. Bills have been submitted to Congress that would make unlawful the present English units now in general use.

Practical engineers and in fact all fair minded people of intelligence know that if such legislation were enacted it would produce a chaotic condition in every line of human endeavor.

We are glad to be able to present to our readers the interesting and practical plan for the establishment of an international precision value for the inch proposed by Luther D. Burlingame of the Browne & Sharpe Mfg. Co., Providence, R. I., which will be found elsewhere in this issue. We commend its favorable consideration to all those who are seeking means of improvement upon or simplification of the English units now in international use.

Railway Employe Accidents Reduced

A reduction of approximately 18 per cent was shown in the accident rate of all railway employes on duty during the first four months of 1928, as compared with the corresponding period last year, according to the Bureau of Statistics of the Interstate Commerce Commission. An improvement was shown by every department connected with railroad operation.

This is the direct result of the safety campaigns which the railroads have been aggressively conducting on their individual lines during the last few years.

The measuring rod which the Commission applies in determining the relative degree of safety is the figure showing "casualties per million man-hours." This covers the actual number of hours worked by all employes of the steam railroads during the period under consideration.

The Commission finds that casualties per million man-hours, covering both killed an dinjured employes on duty, in the first four months of 1928 stood at 17.08, a reduction of 3.74, or 17.9 per cent, as compared with the first four months of 1927.

Casualties per million locomotive-miles (killed and injured), which covers both employes and passengers, amounted to 24.41 for the first four months of 1928, a reduction of 3.19, or 11 per cent, as compared with the corresponding period of 1927.

However, persons killed in highway grade crossing accidents in the first four months this year totaled 697, an increase of 28 as compared with the same period last year.

For the four-month period this year, 1,826 highway grade crossing accidents were reported, compared with 1,746 for the same period in 1927, or an increase of 80.

Persons injured in such accidents totaled 2,073, or an increase of 74 compared with the first four months in 1927.

In the month of April this year, 180 persons were killed in highway grade crossing accidents, or an average of 6 persons daily.

The railroads of this country have been, and are conducting a widespread campaign in the hope of bringing about a reduction in the number of such accidents, as well as a reduction in the number of casualties. Everything possible is being done to provide the greatest measure of safety at such crossings.

The complete elimination of highway grade crossings is both physically and financially impossible. The number of automobiles in use is constantly increasing and, for that reason, the continued co-operation of the public and the rail carriers is imperative, if a material improvement in highway grade crossing safety is to be attained.

Hudson Type Locomotive for the B. and A.

The Schenectady plant of the American Locomotive Company has delivered the first of a series of five large passenger locomotives of the Hudson type, J-1-B, for the Boston and Albany Railroad of the New York Central Lines. The new engine, numbered 600, is the largest of the Boston and Albany system and will be used exclusively for passenger service between Boston and Albany.

It weighs about 352,000 pounds and has a tractive power of 43,500 pounds, and with booster 58,100 pounds. It has a four-wheel engine truck, six-wheel and four-wheel trailer truck. The drivers have a diameter of 75 inches. The locomotive operates on 240 pounds steam pressure.

A Precision Value for the Inch*

By Luther D. Burlingame, Browne & Sharpe Mfg. Co.

The agency in the United States which is charged by the Federal Congress with the custody of the primary standards of weight and measure, the U. S. Bureau of Standards in Washington, has just made an announcement of importance. Through its director and spokesman, Dr. George K. Burgess, it has declared that it "neither advocates nor discourages the adoption of the metric system of weights and measures."

At an informal conference attended largely by the officials of the several States whose work is concerned with the administration of the States' weights and measures laws and regulations, Dr. Burgess said (May 22, 1928):

"The whole subject of the compulsory adoption of the metric system in the United States is a highly controversial one, and diametrically opposite views are being freely voiced. . . So many factors enter into the equation that the Bureau is disinclined to make the attempt to evaluate it, and thus throw the weight of its decision upon one side or the other."

The fact is that due to circumstances over which the present officials at the Bureau had no control, the primary standards of length and mass on which the Bureau of Standards depends, are actually not the standards which the people of this country use, but are the metric-system standards. The Meter and the Kilogram, which are copies of the International Meter and Kilogram preserved at Sevres, France, are, for example, used as primary standards of length and mass, instead of the yard and pound.

Reasons for Bureau of Standards' Standards

The challenging question arises as to why primary standards are not prepared and used based on the units in common use, instead of applying the round-about method of working from metric standards and translating into English standards.

While one of these reasons is undoubtedly that the officials of the Bureau, like many other scientists, regard the metric standards as the highest grade precision standards, the most plausible reason seems to be that they were "inherited" from the Coast and Geodetic Survey branch of the Treasury Department when the Bureau was created by Act of Congress in 1901.

It is a long story as to why the copies of the meter and kilogram came to be used in Washington as primary standards,—too long to relate here.

Attempts to Enforce the Metric System

Though the United States inherited and has continued to use the English standards of weight and length, there have been repeated and persistent efforts to crowd them out and to force the use of metric units in their stead.

The first fruition of these attempts resulted in the metric system being made legal for all contracts by an Act of Congress in 1866. By this Act the metric standards were placed on a parity with the English standards, and as a matter of fact the Act contained a table of equivalents of English and Metric units so that the Metric units made legal could be derived from the customary units then—and now—in use.

In this Act of Congress of 1866, the Meter was defined as 39.37 inches, which, it should be noted, established an American Meter in terms of our customary standards, many years before the organization of the International Bureau of Weights and Measures at Sevres in 1875.

With the development of science in the eighties, the leadership of those working to make the metric standards universal, resulted in those standards being given much more prominence than the English standards. Also the controversy between the Metric standards and the English standards undoubtedly acted to hold back the precise determination of the English standards.

Thus it was that when the light-wave method of calibrating material standards was suggested and developed, it was applied to the calibration of the Meter, and as early as 1894 the meter was measured in light waves. The yard could just as well have been measured by the same method, but as far as known no direct measurement of the yard in light waves has been made.

A recent development was when representatives of the nations, assembled at the Seventh International Conference on Weights and Measures in the fall of 1927, agreed to accept the length of the International Meter as 1,553,164.13 wave lengths of the red ray of cadmium as being the most accurate determination up to the present time. For convenient visualization in terms of our units, a wave length of the red ray of cadmium is about a quarter of a ten thousandth of an inch.

Many years ago the British authorities, naturally requiring to know the relation of Imperial Yard to the meter, to precision, secured an Order of Council (May, 1898) by which Yard was defined as 0.914399 meter, and this is the precision value of Yard used since that time.

How the Metric System Has Introduced Controversy

The question of the independent value of the English standard of length, versus its derivation from the international meter, has been a source of controversy in the United States for many years, and it would seem that the issue is still far from settlement.

The basis of the difficulty is:

1. The incommensurability of the English and metric standards.
2. The acknowledged refinement of workmanship of the international meter bar.
3. The controversial legal situation in the United States.
4. The lack of precise workmanship on the English standards reported as unequal to that on the metric standards.
5. The controversial legal situation in Great Britain.

In the United States, the status of International Meter in its relation to the Yard rests entirely on an "authorization" of a Secretary of the Treasury promulgated in 1893. This relation as interpreted by the Bureau of Standards has never been legalized by Congress, it being provided in the Constitution that Congress alone shall "fix the weights and measures." This has led to confusion and controversy, those who favor the metric standards and the metric system interpreting the old Act of 1866, already referred to, as meaning that the Yard shall be 3600/3937 meter, instead of giving the Act what many consider its true interpretation, that meter as used in this country shall be 3937/3600 yard.

This accounts for such statements as one finds in publications on length standards. For instance, official paper No. 535 of the U. S. Bureau of Standards, entitled "A Fundamental Basis for Measurements of Length," by H. W. Bearce, Senior Physicist of the Bureau, and published in 1926, has as its opening paragraph:

1. *Relation between yards and meters, inches and millimeters:* There is at present a slight difference in the

* A paper prepared for the American Institute of Weights and Measures.

legal or official relation between yards and meters in the United States and Great Britain. In the United States the official relation is:

$$\frac{1 \text{ yard}}{1 \text{ meter}} = \frac{3600}{3937}$$

In Great Britain the official relation is:

$$\frac{1 \text{ yard}}{1 \text{ meter}} = \frac{3600}{3937.0113}$$

From these relations may be derived the following approximate relations:

1 United States inch = 25.40005 millimeters
1 British inch = 25.39998 millimeters

The reason for claiming that the relation between Yard and Meter in the United States is 3600/3937 has been mentioned. The 3937.0113 value for Great Britian is derived from the Order of Council of 1898, also already given here, fixing yard as 0.914399 meter. In England this Order of Council has presented two difficulties. In the first place it fixes the yard independent of the Act of Parliament of 1878, which defined Imperial Standard Yard as the distance between two lines on a certain bronze bar. Also the Order defines Yard at 62 degrees Fahrenheit, whereas the Meter is Standard at 0 degrees Centigrade.

Standards of Great Britain and United States Identical

It is thus only when considered in reference to and in terms of the International Meter, as above explained, that there is any difference between the length standards of Great Britain and the United States. In fact those manufacturers of the two countries who have daily dealings in length standards, even in precision standards used in tool and gage manufacture, refuse to recognize that there is any difference in the standards of the two countries. Nevertheless the fiction that there is a difference has spread widely, and is incorporated today in the scientific and engineering literature of the world. It is moreover accepted in Germany and France, where a great deal of manufacture in the Inch is carried on today. Hence it is important to have this fiction eradicated as soon as possible.

Inch, Controlling Unit, Should Be Made Precise

The situation to day in respect to the fundamental standards of length is that neither in Great Britain, Canada, the British Commonwealths, nor in the United States, is the meter and its parts in everyday use in places in which length measurements are employed, except to a comparatively small extent. The inch, with its decimal subdivisions for precision, and fractions for round dimensions, is the almost exclusively used unit in these countries for the production of manufactured articles. Moreover, the inch is fast extending as the standard length unit for manufacture throughout the world. It has no disadvantages whatever for this purpose, and has distinct advantages over metric units of length.

The inch which is so generally used in manufacture, and which is probably the most important unit in the world today has, however, no legal definition. We all know it is the thirty-sixth part of a yard, but from what has been said here the question of what a yard is in law is today a matter of interpretation, leading to controversy.

One thing we do know about the standards of length is that the International Meter has now been stabilized for the time being, at 1,553,164 wave lengths of the red ray of cadmium. Whatever the general opposition to the metric system and the metric standards, it would seem the better part of wisdom to accept this value. Some will argue that fixing the wave-length value of the meter makes the wave length the primary standard, and that the meter bar as a standard is thereby done away with; but for some time to come we shall need tangible and material standards, and a platinum-iridium bar is a more tangible standard than a ray of light.

The Inch-Millimeter Practical Gear Ratio

The acceptance of the determination of the light-wave value of the meter points the way to the practicability of also determining the yard, the foot and the inch, in terms of red rays of cadmium and in a specified relation to the meter. As has been shown, the scientists in Great Britain define the inch as 25.39998 millimeters, while those in this country define it as 25.40005 millimeters. The mean of these two values is approximately 25.4 inches, and as a matter of fact this is the value which is always used in manufacturing, where inches need to be converted readily to millimeters and where an error in the fifth decimal place is not material.

For the *mechanical* conversion of inches to millimeters a conversion factor with a small number of figures is most practicable. The figure of 25.4 has this advantage as it allows the use of a gear ratio of 5 to 127, so that if a screw cutting lathe, for example, is built to inch dimensions and has its lead screw cut to inches, a gear ratio obtained by using a 127 tooth gear in the train will give a feed in millimeters; and in the same way any machine having its lead screw in millimeters can be used to produce screws or other parts dimensioned in inches.

I, by about equal concessions on the part of Great Britain and of the United States, duly authorized by law in the two countries, the inch could be agreed upon as 24.4 millimeters, the manufacturers of these countries would probably be willing to accept this as the basis of the inch.

Light-Wave Value of Inch, Foot, Yard

Accepting the value of international meter as 1,553,-164.12 waves of the red ray of cadmium, and accepting the conversion factor of inch=25.4 millimeters, would give the number of light waves in the inch by simple multiplication:

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1,553,164.13
        25.4
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  6 212 656 52
 77 658 206 5
310 632 826
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394 503 689 02
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Inserting the decimal place, this is 39450.368902 wave lengths in an inch.

The question arises of how many significant figures are necessary, and this is arrived at *practically* when we remember there are 12 inches in a foot and 3 feet in a yard. The number 12 immediately suggests that the decimal .368902 is very near to one-third, using which makes 39450 1/3 wave lengths in an inch. Multiplying by 12 gives the number of wave lengths in a foot as 473,404, even; and multiplying this again by three gives the number of waves in a yard as 1,420,212, also an even number.

Temperature and humidity corrections should be mentioned briefly, because they too cause variations leading to controversy. The International Meter is standard at 0° Centigrade, the Imperial Yard at 62° Fahrenheit. In the United States the working temperature for standards is 68° Fahrenheit. For material standard bars the temperature of the bar is of great importance, but humidity of the air is of no importance. In wave-length determinations temperature is of less importance, and humidity is a controlling factor.

Comparison with Accepted Meter Value

The paper of the Bureau of Standards already cited proposes that yard be defined as 1,420,213.28 wave lengths. This figure is derived from the figure of 1,553,164.12 waves for the meter, the same figure as we have used, using the conversion factor of 1 yard = 0.9144 meter. It is known that this latter conversion factor has not to date been acceptable to the British authorities. The British Order of Council defines Yard as .914399 meter, and it may be that this is difficult to get changed, especially since .9144, the United States factor, is known to vary from the exact ratio even more than the Order of Council figure.

Summary of Proposal for Precise Inch

It would thus seem advisable to recommend that the United States, Great Britain, Canada and the other British Commonwealths, accept the value of International Meter of 1,553,164.13 wave lengths, and then agree on the conversion factor of 1 inch equals 25.4 millimeters for practical use, and further agree on establishing the wave length value of the inch as 39540 1/3 waves as fundamental.

It is seen that this will act to give the inch its precise value and relative status which all desire so urgently.

In the United States the acceptance of such a proposal would probably remove much of the opposition to the Order, approved by the Secretary of the Treasury in 1893, which is claimed to have given the metric standards an authority which Congress has never intended them to have.

This would not only pave the way for accord between Britain and America, but would also bring scientists and manufacturers and the Government departments in the United States itself to a better mutual understanding.

Recommendation for New Primary Standards

The acceptance of this proposal should be followed by the making of physical standards for the foot, yard, etc., having at least the same degree of refinement as the present metric standards. These could then be used as fundamental without conversion from metric when comparing industrial standards, and also as a basis for whatever precision work on length standards is done from now on.

The Relation of Brakes to Slack Action and Train Shocks

The relation of the air brake to slack action and shocks in train operation was dealt with in the report prepared by the Pittsburgh Air Brake Club and presented at the last convention of the Air Brake Association. According to the report the principal factors entering into the production of shocks in long trains by the applications of the brakes are:

1—Amount of and rate of developing braking force at the head end of the train; amount of brake application, brake pipe leakage and piston travel.

2—Throttle manipulation.

3—Track condition, as to grade and curvature.

4—Speed.

5—Free slack between cars.

6—Type and condition of draft gear and attachments.

All factors being the same, the amount and rate of braking effort developed on the head end of a train in advance of that developed on the rear determines the difference in impact velocity created when the slack runs in, and therefore the severity of the resulting shock. When the brakes are applied from the locomotive, they apply serially from the head end toward the rear end which results in the head end being retarded first. The time of serial application is a little shorter with a heavy reduction than a light one, but nevertheless the retardation set up on the head end is greater in proportion as the initial brake application is heavier. It is for that reason that the split reduction is so generally resorted to in order to allow the slack to close in and adjust itself gradually.

Brake pipe leakage is a highly important and most serious factor in increasing the rate of developing retardation and, therefore, in causing shocks. Naturally the more leakage the less control the engineman has over the rate and degree of brake pipe reduction and particularly in the front portions of trains. Thus differences developed in the retarding force between the front and rear will be greatly increased. This is one of the best reasons for keeping brake pipe leakage to the lowest possible figure since it is one of the factors that can most readily be controlled.

Variations in piston travel varies the retarding force developed with any given brake pipe reduction so that in extreme cases it may be the cause of bad slack action in the train. This cause is, of course, beyond the control of the engineman and no change in service brake manipulation can fully overcome it, particularly, where combined with heavy brake pipe leakage. The recent change in the A. R. A. specification for piston travel from 6 inches to 8 inches, to 7 inches to 9 inches will be highly beneficial if it is carefully observed. This change clearly makes for a more flexible and smoother brake for level road service. Contrary to the belief of many, it makes for better flexibility and equal safety for grade service.

The less the load in the freight car, the greater the retarding effect of the brake on that car. Therefore, with empty cars on the head end of a train greater shocks are liable to result due to brake application than where such cars are loaded. Loads on the rear end with empties ahead would result in greater shocks than with an empty train, due to the greater weight of the loaded cars behind. With loads ahead and empties behind, the shocks due to slack running in are not likely to be so severe because of the lower braking ratio of the loaded car. However, as the loaded cars would start to brake more quickly, the slack will still close in. On the other hand, if the initial speed be high enough to allow time for a reversal of slack, due to the more effective braking power of the empty cars on the rear, there is a possibility that the slack may run out again with sufficient force to part the train. This is also another reason why the split reduction is usually found of great advantage.

Braking with the open throttle is common practice as it has a tendency to minimize the retarding effect of the brakes on the head end and reduce the danger of shock from the rear cars running in and then running out hard. While there are some differences of opinion as to the manner in which the throttle should be handled at such a time, there does not seem to be any question but that it is a decided assistance in handling the slack.

Another consideration of great importance is that of track condition at points where brake applications must be made. Curvature and grade are factors which have a very important bearing on the amount and type of brake operation. Making a brake application with the head end entering a sharp curve or on an ascending grade with the rear end on straight level track, or descending grade creates a condition where the engineman must take special precautions satisfactorily to control the rate of closing the train slack. These are conditions which have to be met by good judgment combined with a knowledge of the position of the slack at the time and place where the stop is to be initiated.

There is usually a critical speed for a given set of conditions as to train make-up, brake pipe leakage, road bed, etc., where shocks, due to slack action, will be the maximum. This is usually a fairly low speed and it should be the practice under such speeds to handle the brake with great care. For the critical condition, the head end will be just brought to a stop at the instant the slack closes in at the rear. When the speed is lower than this critical point, the energy in the train is less and results in reduced shock as compared with the critical speed. On the other hand, if the speed is higher, the retardation at the head end will be at a lower rate, due to lower brake shoe friction, and consequently the shock will be less.

Other things being equal, the greater the amount of slack the higher the critical speed will be and the greater the possibility of damage due to shock. It may be said without question that the amount of shock possible to obtain, increases in severity in proportion to the amount of slack. Slack of itself does not create shock, but if there were no slack there could be no shock.

Investigations have been made recently on several railroads which have revealed an undesirable condition of slack and draft rigging. The slack in a large number of freight trains has reached a point where, under critical track conditions, it is conducive to rough handling and in some cases break in twos.

Air brake supervisors have been kept busy formulating rules for handling these trains and it now seems that their ingenuity has become exhausted. We feel, therefore, that it is time to call attention to this condition with the hope that some action can be taken at this convention to bring the question of train slack and value of draft gear up for the consideration of the American Railway Association.

During a recent investigation on an Eastern railroad, it was found that in a train of 95 loaded coal cars, there was as much as 100 ft. of slack. In an investigation on another Eastern road, it was found that the slack ranged from 49 ft. per 100 cars, as the best condition encountered and involving a train of comparatively new cars, to a maximum of 103 ft. The average for 14 trains, taken at random, was 70 ft. Of course, these figures for slack do not represent free or unrestricted slack alone, because the measurement was taken by slackening a road engine back, then forward, with the rear end of the train anchored by a helper engine. Recently some 363 passenger cars in 31 different trains were investigated to determine the free slack existing in couplers and it ranged from ½ inch to 2⅜ inches per car. The average for all was 1.41 inches per car. On 100 of these cars 31 per cent had one inch free slack, 17 per cent had 1¼ inches; 11 per cent, 1½ inches. Only 25 per cent were less than one inch. On a few cars, the free slack at one end was ¾ of an inch and on the other end 2 inches. This was all free, unresisted slack. The total slack by bunching and stretching the train ranged from 2¼ inches to 6⅞ inches per car, and the average for all was 4.9 inches. It was noticeable that those trains having the greatest number of head end cars, such as baggage, express and mail cars, always developed the most slack.

In view of the fact that neither the A. R. A. nor any railroad of which we know, has any rule or specified procedure for checking up and limiting the amount of free slack in draft rigging, it is obvious that this situation justifies serious consideration leading to definite corrective action. The 5⅛ in. limit between the knuckle and guard arm of the coupler head represents a 7/16-in. allowance from the 4 11/16-in. dimension given for the standard No. 10 coupler contour. This A. R. A. limit has been specified only to insure that couplers will remain coupled and has no direct relations to the question of free slack.

It has been argued that a certain amount of free slack is necessary to facilitate the starting of long trains, but certainly no one can take the position that as much free slack is necessary as represented by the foregoing figures: otherwise, those trains cited which have a minimum of slack are inadequately provided with free slack for suitable starting and certainly that contention has never been heard.

It is generally accepted that a friction draft gear of suitable design is much better protection against shocks than the older spring type gear; but, leaving out of consideration friction draft gear having a relatively low value when in perfect condition, many so-called friction draft gears are, on account of extended wear and lack of maintenance, offering but little, if any, better protection to the car than the ordinary spring gear. Others, because of being in a jammed condition, do not provide the protection that is characteristic of friction gears when properly maintained.

Of course, a large majority of the shocks experienced by the freight car occur during switching movements, and in these the amount of free slack is probably not of any consequence. The basic value of new gear and condition of the draft gear, however, is decidedly of consequence.

In very recent years the railroads have been realizing beneficial returns in many ways from the improved maintenance of air brake devices. The condition of train slack, as briefly reported, indicates the necessity for a similar orderly, systematic and vigilant campaign of maintenance of draft rigging.

The condition of the draft gear and attachments on cars on repair tracks is generally an unknown quantity; better stated, just how bad the condition may be is unknown, for these parts get little, if any, attention.

It is recommended that this matter be referred to the A. R. A. with the suggestion that suitable rules for interchange be adopted which will define permissible limits of wear in draft gear and couplers and provide suitable periodic test specifications to insure the maintenance of these devices within these limits, and thereby secure a reasonable control of free slack between cars.

First Locomotive in Canada

The first locomotive to run in Canada was the "Dorchester," a 2-4-0 engine with a four-wheel tender, built by Robert Stephenson & Company, Newcastle-on-Tyne, England, and the first trip, one of 14 miles, was made on July 21, 1836, on the line from Laprairie, southward to St. John, Que., which now is a part of the Canadian National Railways, according to a report published in a Montreal newspaper of 1836. The name of the road at that time was the Champlain & St. Lawrence.

Copper Bearing Steel in Freight Cars*

By DR. J. S. UNGER, Research Manager, Carnegie Steel Company

About 20 years ago a few investigators observed that certain steel sheets, which were made by the same process showed considerable differences in resistance to atmospheric corrosion. The ordinary chemical analysis regularly made for the four common elements, carbon, manganese, phosphorus and sulphur showed little difference in their composition. On making more complete analysis, determining the presence of other than the usual elements, it was found that small amounts of copper were present in those sheets which were corroded the least.

Such findings were amplified by making steel sheets by the same method, but adding small amounts of copper to certain ingots of the same heat, then rolling into sheets, afterwards exposing both kinds of unprotected sheets to the atmosphere and noting the relative difference in corrosion.

Up to this time there had been a metallurgical tradition to the effect that steel containing copper was red-short and of poor quality. This tradition had been believed by many metallurgists, who had prepared specifications in which the steel was rejected if it contained above a certain low percentage of copper. When copper was added to steel, it appeared to be a display of metallurgical ignorance to deliberately add a supposedly injurious element.

This same belief was not alone true of copper, but similar experiences have been met with in the traditions regarding other elements, notably phosphorous and sulphur. It has been estimated that the loss from rusting amounts to $300,000,000 annually in the United States. The railroads, being large users of steel, share a considerable part of the loss. Among the items affecting losses from rust, the steel car is one of the most important.

The life of the steel freight car is dependent upon several factors among which are mechanical abrasion and corrosion. The character of the loads carried governs the destruction of the car body by mechanical abrasion, and may also affect the corrosion to some extent. Regardless of the loads carried the cars are subjected to atmosphere abrasion, will finally cause the destruction of the car body. Very little can be done to reduce the mechanical abrasion. Consequently, efforts to increase the life able part of this loss. Among the items affecting losses due to corrosion.

As a result of the experiences with small amounts of copper in roofing sheets, the Bessemer & Lake Erie, early in 1914 decided to try copper bearing steel in the bodies of some of its steel freight cars to determine the effect on the life of the car. As no two cars are used under exactly the same condition of service, and the life of the individual car is largely dependent upon the service to which it has been subjected, it is necessary when comparing different kinds of steel to make the trial in the same car. In order to make this test comparative and of sufficient magnitude to give definite information, the Bessemer & Lake Erie ordered 100 hoppers and 100 gondolas to be built, using copper bearing steel in one half of the body and plain steel in the other half of the same car.

Both the hopper and gondolas were of 100,000 lb. capacity. The side and end plates in both kinds of cars were ¼ in. thick. The floor plates in the gondolas, and the floor in the hopper and hood cover plates in the hoppers were 5/16 in. thick. The center-sill cover plates in the gondolas, and the drop-door cover plates in both kinds of cars were ⅜ in. thick. It will be noted that some of these plates were thicker than ordinarily used, but as both kinds of steel were of the same thickness, the test was truly comparative.

The cars were placed in scrivce during October, 1914, and to date have been in service for about 13½ years. All the cars are still in service with the exception of a few that are laid up for repairs.

The condition of these cars has been carefully observed by both the Bessemer & Lake Erie and the Carnegie Steel Company during the period they have been in use. It has been difficult to make an inspection of a great many of the cars at any one time, due to the fact that the cars are widely distributed over the Bessemer & Lake Erie and also on connecting lines.

The first inspection was made after the cars had been in service about two years. This inspection showed the characteristic differences between the copper bearing and the plain open hearth steel that are usually found when comparative atmospheric corrosion tests are made of the two kinds of steel under the same conditions. The unpainted surfaces of the plain steel were a light, yellowish brown color, with loosely adhering rust. The copper bearing steel was of a dark, reddish brown color, with a dense, tightly adhering coating of rust. The plain steel was pitted to greater extent, and the pitting was much deeper than on the copper bearing steel. The most noticeable difference in the two kinds of steel at the end of two years' service was the condition of the paint. The paint was adhering much better to the copper bearing steel than it was to the plain steel in similar locations in the same car. The difference in the adherence of the paint was borne out by all subsequent annual inspections of the cars. After the cars had been in service sufficiently long, it was an easy matter for anyone not familiar with these cars to decide which was copper bearing steel and which was plain steel, simply by the condition of the coating of paint. In many cases the copper bearing steel would be well protected by the paint, while practically no paint remained on the plain steel in similar locations. This resulted in the plain steel being corroded to a greater extent on the outside of the car body than the copper bearing steel, as indicated by considerably more and deeper pitting on the plain steel.

The influence of the two kinds of steel on the adherence of the paint has also been a factor in the cost of maintenance. In many cases cars had to be repainted simply because of the failure of the paint coating on the plain

TABLE I

COMPARISON, OF THICKNESS AFTER SIX YEARS' SERVICE

	Copper-bearing Steel			Plain O. H. Steel		
	Original Thickness, Inches	Thickness After 6 Years, Inches	Per centage of Loss	Original Thickness, Inches	Thickness After 6 Years, Inches	Percentage of Loss
Gondola 14105						
Floor plate.....	.313	.287	8	.313	.256	18
Side plate.....	.250	.237	6	.250	.220	12
Gondola 14124						
Floor plate.....	.313	.285	9	.313	.250	20
Side plate.....	.250	.240	4	.250	.225	10
Gondola 14190						
Floor plate.....	.313	.270	13	.313	.230	26
Side plate.....	.250	.240	4	.250	.225	10
Hopper 41035						
Divide sheet....	.250	.220	12	.250	.170	32

Average loss of copper-bearing steel, 8 per cent; average loss plain O. H. steel, 18 per cent.

* Abstract of a paper presented before the Railway Club of Pittsburgh.

steel portion, while all the cars had to be repainted more frequently than would have been necessary if the bodies had been built entirely of copper bearing steel.

After the cars had been in service for six years, measurements were made of the thickness of the plates in similar locations in four separate cars. Table I gives the results of the measurements. It will be noted the average results at this time showed that the copper bearing steel had lost 8 per cent of its original thickness, while the plain steel in similar locations had lost 18 per cent of its thickness.

Measurements taken at subsequent inspections showed that in every case the plain steel was considerably thinner than the copper bearing steel. Where abrasion has been a more important factor than corrosion, as in the side hopper sheets, the relative difference in the loss in thickness has not been as great as when the comparison is made between the two steels in a location where there has not been as much abrasion, as in the side sheets of the gondolas. In the latter case corrosion has been more of a

TABLE II

COMPARISON OF THICKNESS OF OUTSIDE HOPPER SHEETS AFTER 13 YEARS' SERVICE

	Original Thickness, Oct., 1914, Inches	Copper-bearing Steel Thickness, Oct., 1927, Inches	Plain Open-hearth Steel Thickness, Oct., 1927, Inches
	.313	.180	.165
	.313	.200	.140
	.313	.215	.100
	.313	.220	.115
	.313	.205	.160
	.313	.220	.175
	.313	.232	.107
	.313	.230	.135
	.313	.220	.130
	.313	.220	.110
Average thickness	.313	.214	.134
Loss in thickness	....	.099	.179
Per cent loss	....	32	57

factor and the copper bearing steel shows a greater superiority than it does in the side hopper sheets of the hoppers.

This is shown in Table II, which gives the average thicknesss of the two kinds of steel in similar locations in the same cars after 13 years' service.

Again using the loss in thickness for plain open hearth steel as 100 per cent, the copper bearing steel lost 55 per cent as much metal as the plain steel.

The results with the two kinds of steel in the hoppers were further confirmed by work done by the Bessemer & Lake Erie. Hopper 41071 was returned to the shops after 13 years' service for general repairs, which included replacements of a number of the plain steel sheets. While it was not necessary to remove the copper bearing steel in similar locations at this time, the Bessemer & Lake Erie officers removed the cross hood and diaphragm, inside hopper sheets, outside hopper sheets, center floor plates, intermediate side sheets and the side floor sheets of both kinds of steel. These sheets were then carefully cleaned and weighed to determine the loss in weight. Table III gives the relative loss of weight for the two kinds of steel in similar locations in the same car.

It will be noted that the loss in weight for the copper-bearing steel was 61 per cent as much as the plain steel. This is in fairly close agreement with the relation found when the losses were determined by measuring the thickness of the side hopper sheets as shown in Table II.

Most of the hoppers have now been in service long enough to require general body repairs. These repairs are in places where the mechanical abrasion and corrosion have been most severe. In cases where the repairs have consisted of patches put on over the original steel, as on the bottom of the side hopper sheets, the patches in many cases have been put on over both kinds of steel. Examination of the edges of the steel sheets under such patches show that the plain steel has been worn to a ragged knife-like edge, while the copper steel in the same location would be 1/8 inch or over in thickness. This indicated that while it was necessary to patch the plain steel, the copper bearing steel would have lasted much longer, but the shops considered it cheaper to make repairs to both kinds of steel at one shopping of the car.

This has not been the case where the cars were given extensive repairs. During the last inspection one gondola car was examined in the shops in which the plain steel end had been replaced, while no replacement was

TABLE III

COMPARISON COPPER-BEARING AND PLAIN OPEN-HEARTH STEEL REMOVED FROM BODY OF A STEEL HOPPER CAR AFTER 13 YEARS' SERVICE

		Original Weight, Oct., 1914, Lb.	Weight After 13 Yrs., Lb.	Loss in Weight Lb.	Loss in Weight Per Cent
Cross hood and diaphragm	Plain steel	796.6	422.5	374.1	46.9
	Copper steel	796.6	506.5	290.1	36.4
Inside hopper sheets	Plain steel	256.9	139.5	117.4	45.7
	Copper steel	256.9	161.5	95.4	37.1
Outside hopper sheets	Plain steel	324.8	163.0	161.8	49.8
	Copper steel	324.8	231.5	93.3	28.7
Center floor sheet	Plain steel	144.7	80.5	54.2	44.4
	Copper steel	144.7	108.0	36.7	25.4
Intermediate side sheet	Plain steel	516.8	263.5	253.3	49.1
	Copper steel	516.8	468.5	48.3	9.3
Side floor sheets	Plain steel	1330.9	795.5	535.4	40.2
	Copper steel	1330.9	973.5	357.4	26.8
Total	Plain steel	3370.6	1864.5	1506.1	44.7
Total	Copper steel	3370.6	2449.5	921.1	27.3

necessary in the copper bearing steel. Hopper 41080 was also in the shops at this time. The men in the shops were not familiar with the fact that different kinds of steel had been used in this car, but had replaced such parts as in their judgment required replacement. The plain steel end sheet, floor sheet, and outside hopper sheets had been replaced by new sheets. The copper bearing sheets in the same location were considered sufficiently good for further service and were not replaced. Another hopper was also inspected in one of the yards, which had been repaired some time previously. This car also had new end and floor sheets put in the plain steel half, while the original copper bearing sheets were still in use.

A pronounced difference is noticeable in the cars, aside from the question of the paint previously noted. The copper bearing sheets are comparatively straight and free from serious bulges, dents or bends. The plain open hearth steel sheets are dented and bent out of shape to a much greater extent, indicating that they have become thinner in gage. In a number of the cars it is possible to determine which is the plain and which is the copper bearing steel by this difference in appearance. In addition to this difference noted one gondola was inspected in which the plain steel floor plates were worn and rusted completely through at several locations, while the copper bearing floor plates were still in good condition. One hopper was inspected in which the plain steel side sheets had rusted through in two different locations. The copper bearing steel side sheets in this car were comparatively straight and gave no evidence of failure in the near future.

The plates and structural shapes used in the bodies of these cars amounted to about five tons in the gondolas and six tons in the hoppers. Since it is the body of the car that fails first, and ordinarily measures the life of the car, if copper bearing steel were used exclusively in the body, the average life would be increased from one-third to one-half, or in round numbers, from five to eight years. This additional life more than justifies the slight extra cost per ton for the copper steel.

Our experience and observation of these cars may be summarized as follows:

1.—Paint adheres very much better to copper bearing steel in a car body than it does to plain open hearth steel.

2.—The saving in repainting cars, due to better adherence of paint to copper bearing steel, would be sufficient to justify the use of copper bearing steel in the bodies of steel freight cars.

3.—Where mechanical abrasion has not been a serious factor, as in the side sheets of gondolas, the loss in thickness for the copper bearing steel was only one-third as great as for the plain open hearth steel.

4.—Where the steel was subjected to severe mechanical abrasion as well as corrosion, the loss in thickness for the copper bearing steel was approximately 60 per cent as great as for the plai nopen hearth steel.

5.—From the results of this investigation it can be conservatively stated that the use of all copper bearing steel in the body of the cars would increase the life of the car body from 33⅓ to 50 per cent.

Prevention of Locomotive Boiler Corrosion

A Paper Presented to the Master Boiler Makers' Association

By C. H. KOYL, Engr. Water Service, C. M. St. P. & P. RR. Co.

Since this Association has commenced the systematic study of boiler corrosion, a few years ago, there has been a great increase in knowledge of the causes of pitting and grooving and means of preventing it, particularly in locomotive boilers; and there has been a vast dissemination of this knowledge through the work of this Association and many smaller ones.

There are now three known and proven methods of preventing, or at least greatly reducing, the pitting of locomotive boilers, and though the methods are entirely different in operation yet they all work on the same principle, and this principle I shall try to explain.

You know from your own experience that iron and steel pit only when they are wet. In the case of a boiler tube, it may pit when working and entirely covered by water or it may pit when idle and covered by wet scale. Even plain rusting takes place only in damp air. This means that water is absolutely essential to the process, and when we examine closely enough we find that every atom of iron that disappears from a pit has been actually dissolved in the surrounding water just as does a molecule of sugar or of common salt.

You will remember from last year's meeting that when anything except organic matter is dissolved in water it is partly separated into its component parts; that is, sodium sulphate, for instance, is no longer in solid molecules but is separated into sodium atoms and sulphate molecules. These atoms and molecules travel around independently of each other and for this reason have been called *Ions,* and the process is called ionization or dissociation; and a still stranger fact is that each of these ions is electrified, the metallic ions positively and the other ions negatively, and just enough to balance each other, that is, there is just as much positive electrification as there is negative.

We do not yet know why these dissolving molecules break up physically and electrically, but they do, and the fact of the exact balance of the positive and negative electric charges gives us the key to the prevention of pitting. When an atom of iron goes into solution in the water it carries its positive electric charge with it, and since that would increase the positive charge in the water without equally increasing the negative charge, it follows that somewhere in that water a positively charged ion must get out.

Now, the relative strength of the tendency of these metals to dissolve in water is easily measured and it has been found that the tendency of hydrogen to dissolve in water (you know that hydrogen is the vapor of a metal) is very weak while the tendency of iron to dissolve in water is much stronger, and what happens is that each atom of iron as it leaves the flue forces out of solution an ion of hydrogen. This happens because in ordinary water there is nothing that can be forced out of solution by iron except hydrogen, and just imagine what would happen to the iron atom if it were not strong enough to force out the hydrogen ion. Why, it could not get into the water and there would be no such thing as pitting, nor even ordinary rusting.

This then is the key to all present methods of preventing corrosion of iron and steel under water—just prevent the hydrogen ions from coming out of solution, and you thereby prevent the iron atoms from going into solution, and that means you prevent pitting.

I said that there are three methods which have been successfully tested; and the first is the simplest of all, though in practice it can be used only on soft waters. The method is to deprive the water of its hydrogen ions by artificial means. I shall not attempt to lead you through the chemical reactions involved and it will be sufficient to say that the presence of caustic soda dissolved in water prevents the presence of hydrogen ions, and if there are no hydrogen ions to go out it is useless for iron ions to try to get in.

When we soften water by the lime-soda process, it is a simple matter to use a small excess of both lime and soda-ash and these two substances combine under water to form caustic soda. On the Great Northern Railway, the Water Engineer, Mr. B. W. DeGeer, has used this method with success for some years on the treated-water district. He treats each water, on districts where serious pitting was once experienced, with an excess of both lime and soda-ash, so that each water as it goes to the boiler is almost perfectly soft and contains also from 6 to 15 grains per gallon of caustic soda. As the water is concentrated in the boiler the amount of caustic soda becomes relatively greater, so that from water-change to water-change it averages about 80 or 90 grains per gallon.

Because of this method of treatment and the resultant softness of the water, there is very little sludge in the boilers, and the tendency to foaming is small.

Mr. DeGeer says that before the use of this excess soda, pitting on this district was excessive, now it is light; locomotive flues having a calculated life of ten to twelve years, as against about three years with treated water carrying very little excess caustic soda, and about 2.8 years with raw water.

Method No. 2 uses different means for preventing the discharge of hydrogen ions. You will remember that these hydrogen ions are merely atoms of hydrogen electrically charged, and that each one sails up to a flue and, by touching it, gives up to the flue its little charge of positive electricity. If these atoms were as large as a small bubble or if they came up in sufficient numbers to make a bubble, they would rise to the surface of the water, but they are infinitesimally small and therefore they merely stick to the metal where they touch it and slowly accumulate until the metal is covered by a thin film of hydrogen which separates it from the water.

But as soon as the metal is thus insulated from the water, the next hydrogen ion cannot reach the metal to give up its charge of positive electricity and therefore the next atom of iron cannot get into the water, and therefore pitting is stopped. As long as this film of hydrogen covers the flue there is no pitting, but the trouble is that there is also oxygen dissolved in the water, oxygen from the atmosphere taken up by the water before it entered the boiler) and this dissolved oxygen unites chemically with the film of hydrogen (eats it up) and destroys the wall that separates flue from water, so that the next hydrogen ion can reach the metal and give up its electric charge and the next atom of iron can dissolve in the water, and pitting proceed.

Under these circumstances the remedy is to take this dissolved oxygen out of the water before the water goes into the boiler, and in practice we do it by heating the water to the boiling point before it reaches the boiler, and allowing the oxygen to escape through a half-inch vent pipe in the heater. On the Milwaukee Railroad, on a bad pitting district, we have had a locomotive boiler thus fitted with an open feedwater heater, and for 2½ years we did not find a pit on any flue, while during that time the companion boiler, without a heater, lost nearly all its flues. We now have four more engines similarly fitted and being tested, each on a different kind of water.

Method No. 3 uses still other means of preventing pitting. Mr. L. O. Gunderson of the Chicago & Alton Railroad, the inventor of this third method, recognized the value of the film of atomic hydrogen in preventing the access of hydrogen ions to the metal of the flue, but he accomplishes the same results by coating the flue with an artificial film of metallic arsenic, which, though a metal, still prevents the hydrogen ions from giving up their electric charges to the metal of the flue, and thus prevents pitting just as does method No. 2.

Now, these are not merely theoretical considerations, they are methods in regular use on locomotives. Mr. DeGeer has had the first method in use for several years on the locomotives on the treated-water district of the Great Northern Railway. On the Milwaukee Railroad we have had the second method under successful test on one locomotive on the treated water district for three years, and have now fitted up four more locomotives for the same purpose. On the Chicago & Alton Railroad the third method has been under successful test on three locomotives using softened water for three years, and twenty to thirty more locomotives are being fitted in the same way.

No one of these three men claims to be the first man to have thought out or tested his particular method, but each one claims to be the first to make it work on a locomotive doing ordinary roadwork.

Cleveland Terminal to be Electrified

All passenger trains in and out of Cleveland will be handled by electric locomotives after January 1, 1930, the Cleveland Union Terminals Company has announced. The newly electrified zone is to include about 16 miles of multiple track route, extending from Linndale on the west through the new terminal station to Collinwood on the east. A portion of this electric zone will be on the right-of-way of the New York Central and Big Four lines, and the remainder on the Nickel Plate.

The power distribution will be of 3000 volts direct current, with catenary overhead construction. The motive power for the initial operation will include twenty 204-ton geared-type passenger locomotives.

These locomotives are being built jointly by the American Locomotive and the General Electric Companies. They will have ample capacity for handling Pullman trains weighing as high as 1275 tons trailing, equivalent to seventeen 75-ton Pullman cars. Each unit will weigh 204 tons, with 150 tons on the driving axles. The six geared driving motors will have a total rating of 2900 horsepower at the one-hour rating, and 2465 horsepower at the continuous rating. At each end of the locomotive is a two-axle guiding truck designed to insure successful operation at high speeds. The total length of the locomotive is 80 feet, while the length of the cab is only 52 feet. The running gear includes two three-axle Commonwealth Steel trucks coupled by an articulated joint and two two-axle guiding trucks, each carrying a weight of about 27 tons.

The motors are of the usual design for articulated truck-type locomotives, being carried at one side on the driving axle and at the other on the transom through a spring nose suspension. Two cushion-type gears are provided for each motor, one at each end of the shaft meshing with a pinion on each end of the motor. The gear ratio is 79/29. The control is designed as PCL non-automatic, and includes provision for the operation of two or more locomotives in multiple unit. The master controller has main handle, a reverse handle and a field control handle, with suitable interlocking to prevent improper handling. The control provides a total of nine running positions and 33 resistance steps. These steps are distributed as follows:

Motor Connected Six in Series:

- 15 resistance steps
- 1 full-field running step
- 2 reduced-field running steps

Motors Connected Three in Series, Two Such Groups in Parallel:

- 10 resistance steps
- 1 full-field running step
- 2 reduced-field running steps

Motors Connected Two in Series, Three Such Groups in Parallel:

- 8 resistance steps
- 1 full-field running step
- 2 reduced-field running steps

The main circuits are protected by a high-speed circuit breaker which opens ahead of the main contactors.

Current at 1500 vols is supplied by a 3000/1500 volt dynamotor for driving the blowers and some other auxiliary circuits. Low-voltage power for control, lights, etc., is taken from a control generator mounted on an extension of the dynamotor shaft. This generator supplies about 40 volts for charging a 16-cell Exide Ironclad storage battery. The auxiliaries include two 1500-volt motor-driven air compresors and two 1500-volt motor-driven blowers. Electric heaters and some of the other equipment are also operated from the 1500-volt supply.

The train heating equipment on each unit will include an oil burning steam boiler with suitable tank for oil and water, similar to the equipment now being used on the passenger locomotives operated by the New York Central Railroad at New York.

The dimensions, weights and ratings of the locomotive are:

Length inside knuckles	80 ft. 0 in.
Length over cab	52 ft. 0 in.
Height over cab roof	13 ft. 2 in.
Height over trolley locked down	14 ft.10 in.
Rigid wheel base	15 ft. 0 in.
Total wheel base	69 ft. 0 in.
Total weight	408,000 lb.
Weight on drivers	300,000 lb.
Dead weight per driving axle	11,800 lb.
Weight per guiding axle	27,000 lb.
Horsepower six motors, continuous rating	2465 hp.
Horsepower six motors, one-hour rating	2900 hp.
Tractive effort, continuous rating	23,600 lb.
Tractive effort, one-hour rating	29,200 lb.
Speed, continuous rating	39.2 m.p.h.
Speed, one-hour rating	37.3 m.p.h.
Tractive effort at 30 per cent coefficient	90,000 lb.
Maximum speed	70 m.p.h.
Weight of train handled	1275 tons

Questions on Locomotive Design

By Arthur W. Curran

The largest of anything appears to form a great attraction for some people; a fact which is proved by the number of inquiries received by editors and writers, especially in the engineering field.

The subject is a tricky one, however, as many know. The largest locomotive, the greatest tractive power, the biggest grate, the heaviest tender—these are the questions which are easy to ask, but, sometimes, difficult to answer, except after considerable research. Even then, circumstances may render the replies either incorrect or inadequate.

Hence, editors frequently refuse to guarantee the accuracy of replies, or decline to answer queries altogether; since experience shows that someone is almost sure to object to any possible solution of a problem. The resulting controversy does no one any good—least of all the paper concerned!

These thoughts are prompted by a letter which reached me some time since. The letter was courteous enough, and interesting, too; but it contained a number of questions which could not be answered, offhand, by one railroad man in ten thousand! It referred, mainly, to driving-wheel diameter; but this question developed into so many ramifications, in regard to practice both at home and abroad, that a lengthy article would be required to deal with the subject in a satisfactory manner.

Practical men know, of course, that speed is obtained by adequate boiler capacity, rather than by the use of excessively large driving wheels. Before this fact was well understood, however, various attempts were made to "get over the road" by the employment of drivers with diameters ranging from 84 inches upwards. (Mostly upwards!)

Now, if these big wheels could have been turned fast enough, the resulting speed would have astonished a gaping world. As it happened, however, there was not enough steam to do this; boilers of the period being inadequate for the purpose.

The rest is an old story, and simply brings us to the modern locomotive, whose drivers do not exceed 80 inches; and, on many roads, are considerably less than that in diameter.

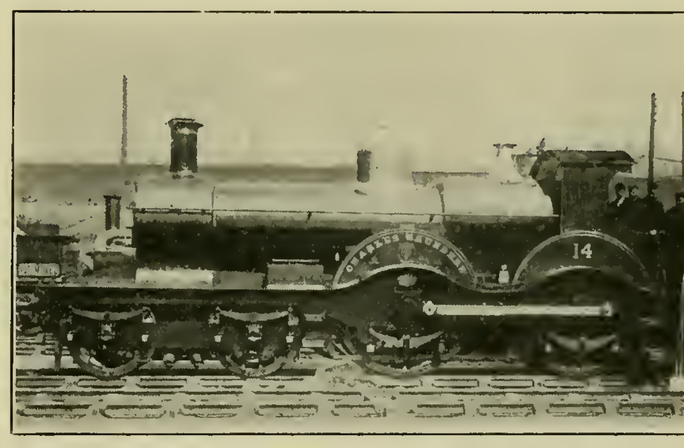
For the benefit, however, of those who may be interested, it may be stated that the largest drivers ever made were 120 inches in diameter, and were fitted to a freak machine known as the "Hurricane" and built for the Great Western Railway of England as far back as the year 1838. Needless to add, the machine was not a success.

In Britain, nevertheless, the notion persisted for half a century that express engines should have a single pair of unusually large drivers. Even when the 4-4-0 type

Locomotive No. 1870 of the North Eastern Railway of England

replaced the "single," big wheels still fascinated the designers of British locomotives.

As evidence of this, the photograph of No. 1870 of the North Eastern Railway may be of interest. This engine was one of five built in 1896, and had driving wheels 91 inches in diameter; probably the largest coupled wheels ever used. The cylinders were 20 x 26 inches; but, as the boiler was only 52 inches in diameter, the class could not have been capable of handling very heavy trains. In fact, at its highest theoretical speed, the tractive power must have dwindled almost to the vanishing point!



Locomotive "Charles Saunders" of the Great Western Railway

In the year 1894, the Great Western Railway built four engines of the 4-4-0 type; these being, oddly enough, the first the road ever had! They were: No. 7, Armstrong; No. 8, Gooch; No. 14, Charles Saunders; and No. 16, Brunel.

A photograph of the Charles Saunders is presented herewith, because the class is pertinent to the subject of this article. The driving wheels were 84 inches in diameter, and actuated by cylinders 20 x 26 inches. Here again, however the small boiler, 51 inches in diameter could not have furnished enough steam for very heavy work.

In due course, these four engines were re-built with larger boilers and smaller drivers; but that is a story with which, at the moment, we are not concerned.

An interesting detail of the picture of the Charles Saunders is the sign, placed in a marker-lamp pocket on the front bumper, and reading: "Not To Be Moved." This, doubtless, was for the benefit of the photographer, who desired a time-exposure.

At about the time when these English engines were built, the New York Central, the Central of New Jersey, the Reading, and perhaps other roads in the United States had 4-4-0 engines with drivers 84 inches in diameter, or slightly over. Later on, there were Atlantic engines on, possibly, half a dozen roads, which had very large drivers.

For the past twenty years, however, nothing larger than 80 inches has been customary; as that wheel-diameter has been found ample for the fastest service. Of course, on hilly roads, a diameter several inches smaller is favored.

I am glad to present these brief notes for the information of interested readers; but have no desire to engage in a controversy on the subject.

Distillate-Electric Cars for the Rock Island

The Rock Island Lines, which undertook a program of motorizing their light traffic lines about five years ago, will shortly add three 800-horsepower distillate-electric cars to their equipment. These cars, the most powerful units so far considered, will be postal car conversions, each equipped with two Electro-Motive Winton 400-horsepower distillate-electric units. They will be used in local and mixed freight service, as well as passenger service, on local and main lines. At the same time, the Rock Island Lines are obtaining eight more single-end, 275-horsepower distillate-electric railway cars, and three Mac two-unit 240-horsepower cars for gasoline.

Motorization of the equipment was started five years ago with two General Electric gas-electric cars. The first four cars motorized in 1925 were conversions of McKeen mechanical-drive cars, with Electro-Motive Winton 200-horsepower engines and General Electric equipment. Seven cars were added in 1926. Five of these were new cars, with 275-horsepower engines burning a low-grade distillate fuel. The other two were 40-foot postal car conversions, each with two 275-horsepower engines, or a total of 550 horsepower. The engines also burn distillate.

The Rock Island Lines have used General Electric equipment in the case of all of their engine-electric motive power units, including drum type K control.

Notes on Domestic Railroads

Locomotives

The Chicago, West Pullman & Southern Railroad has ordered one six-wheel switching locomotive from the Baldwin Locomotive Works.

The Chesapeake & Ohio Railway will build ten locomotive tenders in its own shops.

The Illinois Central Railroad is inquiring for 13 locomotive tenders.

The Mexican Railway Company has ordered 2, three-cylinder, Pacific type locomotives with 20 in. by 28 in. cylinders, from the American Locomotive Company.

The Canadian National Railways has ordered eight 2-10-4 type locomotives from the American Locomotive Company, for service on the section of the Central Vermont north of White River Junction, Vt., to the Canadian border. These locomotives will weigh 415,000 lb., and with tender will have a total weight of 682,530 lbs. The length of locomotive and tender will be 83 ft. They will have a tractive effort of 72,500 lb. without booster and 86,000 lb. with booster.

The Chicago & Illinois Midland Railway has ordered two light Mikado type locomotives from the General Electric Company.

The Cleveland Union Terminals Company has ordered 20 electric locomotives from the General Electric Company.

The Argentine State Railroads contemplate buying about 60 locomotives.

The Northern Western Railway of India has given an order to the General Electric Co., Ltd., London, England, for 2 Diesel-electric locomotives. The locomotives are of the 0-4-4-0 type, comprising a power unit on the main frame carried on two four-wheel bogies, the weight of each locomotive being approximately 50 tons when fully loaded. Each locomotive will be equipped with a six-cylinder 350 b.hp. high speed oil engine, manufactured by William Beardmore & Co., Ltd., Glasgow, coupled to a 200 kw. dc. generator feeding four axle-hung traction motors rated each at 85 b.hp. on the one hour rating at 600 volts. A driver's compartment is provided at each end of the locomotive, the electrical control equipment and brake valves being duplicated.

The Denkmann Lumber Company has ordered one Mikado type locomotive from the American Locomotive Company.

The Hu Len Hei Lun (China) is inquiring through the builders for five Mikado type locomotives.

The Alaska Railroad is inquiring for one Mikado type locomotive.

The Buenos Ayres & Pacific (Argentine) is inquiring through the builders for 8 Mikado type locomotives.

The Missouri-Kansas-Texas Lines has ordered one 33-ton locomotive crane from the American Hoist & Derrick Company.

The Delaware & Hudon Company is inquiring for one Decapod type locomotive.

The Colombia Railway & Navigation Company (South America) has ordered one Consolidation type locomotive from the American Locomotive Company.

The Chicago & Illinois Midland Railway has ordered 1 locomotive of the 4-4-0 type from the Baldwin Locomotive Works.

The Union Railroad Company is inquiring for two locomotive tenders of 7,000 gal. capacity.

The Saginaw Logging Company has ordered 1 2-8-8-2 type locomotive from the Baldwin Locomotive Works.

The Vancouver Harbor Commission, Vancouver, B. C., has ordered one locomotive from American Locomotive Company.

The International Railways of Central America has ordered 4 2-8-2 type locomotives from the Baldwin Locomotive Works.

Passenger Cars

The Missouri-Kansas-Texas Lines has ordered 19 baggage and mail cars from the American Car & Foundry Company.

The Pennsylvania Railroad is now inquiring for upwards of 500 express refrigerator cars.

The Chesapeake & Ohio Railway is inquiring for five gas-electric rail motor cars and 6 trailer cars.

The Chicago, St. Paul, Minneapolis & Omaha Railways is inquiring for 4 gas-electric rail motor cars.

The Chilean Railways will receive bids at 225 Broadway, New York, or at Santiago, Chile, for 20 coaches and 6 sleeping cars. Specifications and drawings are available at the New York office.

The Northern Pacific Railway is inquiring for one business car.

The Oklahoma Railway Company is inquiring for from one to three pairs of passenger motor trucks.

The Southern Pacific System is inquiring for 4 gas-electric rail motor cars.

The Canadian National Railways is inquiring for 3 steel baggage and mail cars, 63 feet long.

Freight Cars

The Cities Service Company has ordered 2 tank cars with two compartments of 3,600 gal. capacity and 2 tank cars with two compartments of 4,500 gal. capacity, from the General American Tank Car Corporation.

The Missouri Pacific Railroad is inquiring for 100 automobile cars of 50-ton capacity and a length of 50 ft. 6 in.

The Chicago, Rock Island & Pacific Railway is inquiring for 10 air dump cars.

The Paulista Railway (Brazil) has placed orders for 1,000 freight cars with builders in the United States.

The Fruit Growers Express has ordered 100 steel underframes for refrigerator cars, from the Pressed Steel Car Company.

The Barrett Company has ordered 16 class 105 tank cars of 50,000 lb. capacity from the General American Tank Car Corporation. These cars are to be used for carrying anhydrous ammonia.

The Argentine State Railroads divided an order equally between the Middletown Car Works and the American Car &

Foundry Company, for 2,200 freight cars of various types and designs.

The Illinois Central Railroad has ordered two air dump cars from the Western Wheeled Scraper Company.

The Erie Railroad has ordered one air dump car of 30 cu. yd. capacity from the Clark Car Company and one air dump car of 27 cu. yd. capacity from the Differential Steel Car Company.

The Cincinnati, Hamilton & Dayton has ordered 6 Hart convertible ballast cars from the American Car & Foundry Company.

The United States Navy Department, Bureau of Aeronautics, has ordered one tank car for carrying helium gas, from the General American Tank Car Corporation.

The Chicago & Eastern Illinois Railway is inquiring for 100 single sheathed automobile cars, of 40 tons capacity.

The Cities Service Company is inquiring for 10 tank cars of 12,000 gal. capacity.

The Hercules Cement Company is inquiring for one cement car.

The International Railways of Central America has ordered 150 box cars from the Gregg Company.

The American Cyanamid Company, New York, has ordered 25 covered hopper cars of 70 tons capacity, from the General American Car Company.

The Manila Railroad is inquiring for six tank cars.

The American Oil Company, Baltimore, Md., has ordered 1 two-compartment tank car of 4,500 gal. capacity from the General American Tank Car Corporation.

The Jacob Dold Packing Company is inquiring for ten steel underframes for refrigerator cars of 30 tons capacity.

The Chicago & Northwestern Railway have ordered 250 40-ton single deck stock cars from the Pullman Company.

The Guayaquil & Quito, Ecuador, has ordered 50 box cars of 22½ tons capacity from the American Car & Foundry Company.

The Missouri-Kansas-Texas Lines has ordered 10 air dump cars from Western Wheeled Scraper Company.

Erie Railroad has ordered 500 steel-sheathed, steel-framed box cars from Pressed Steel Car Company, and 400 automobile cars from the Standard Steel Car Company. Action has not yet been taken on this road's inquiry for 100 furniture cars.

The Chicago, St. Paul, Minneapolis & Omaha Railway has ordered 250 single deck stock cars from the Pullman Car & Manufacturing Corporation.

M. H. Treadwell & Company is inquiring for 1 flat car.

Southern Pacific System will build in its own shops 500 flat cars, 50 gondola cars and 50 caboose cars.

Supply Trade Notes

Wallace R. Lynn, San Francisco, Cal., has been appointed Pacific Coast representative to handle the automotive electrical and radio lines of the **Belden Manufacturing Company**, Chicago.

F. L. Stone, assistant general sales manager of the **Universal Portland Cement Company** has been promoted to general Sales manager to succeed **Blaine S. Smith**, who has resigned to become president of the **Pennsylvania Dixie Cement Corporation.**

Kenneth M. Bailey, has been appointed technical sales representative, with headquarters in the N. O. Bank building, New Orleans, La., of the **Curtin-Howe Corporation**, wood preservation engineers, New York.

George J. Lynch, assistant district manager of the **Chicago Pneumatic Tool Company**, New York, has been appointed district sales manager, with headquarters at St. Louis, Mo.

William H. East, has joined the sales organization of **The Pyle-National Company** as a sales engineer, with headquarters in the Strauss building, Chicago, Ill.

Charles L. Hacket, for many years associated with the **General Railway Signal Company**, has been appointed resident manager of Montreal, Quebec, with jurisdiction over central and eastern Canada.

John S. Latta has resigned as manager of the branch at 2132 Market street, Philadelphia, Pa., of the **Manhattan Rubber Manufacturing Company**, Passaic, N. J. and **David Newhall** has been appointed manager of the Philadelphia branch. Mr. Newhall was formerly manager of sales of freight cars and auxiliary locomotives of the **Bethlehem Steel Company**, at New York.

The Pittsburgh Testing Laboratory has opened an office in Boston, Mass., at 101 Tremont street, in charge of **Donald L. Macdonald.** Mr. Macdonald was formerly connected with the engineering department of **Stone & Webster.**

Grant B. Shipley, engineer of Pittsburgh, Pa., has been elected a director of the **Mond Nickel Company, Ltd.**, of England and Canada. For some time Mr. Shipley has been chairman of the board and president of the American Mond Nickel Company, the United States branch of the Mond Nickel Company, Ltd. Mr. Shipley is also president of the Century Wood Preserving Company, Pittsburgh, Pa.

Maurice N. Trainer and **Edward Barrett Smith** have been appointed assistant vice presidents of the **Amercan Brake Shoe & Foundry Company**, New York, reporting to **William S. McGowan**, vice-president in charge of eastern and southern sales department.

W. G. Edmondson has resigned as assistant engineer of motive power of the Reading Company, and has been appointed works manager at the plant of the **American Abrasive Metals Company**, Irvington, New Jersey.

D. S. Mair, manager of the Houston, Tex., office of **Joseph T. Ryerson & Sons, Inc.**, has resigned to organize the **D. S. Mair Machine Company**, Houston. He will handle the sales of the bolt and pipe threading machines and the taps of the Landis Machine Company and the machine tools of the Ryerson Company.

J. B. Tinnon has been appointed manager of sales of the Thermit department of the **Metal & Thermit Corporation** succeeding W. R. Hulbert, resigned.

Raymond E. Miller, assistant chief engineer of the **Westinghouse Air Brake Company**, Wilmerding, Pa., has been appointed general engineer of the company, succeeding the late **F. H. Parke.** Mr. Miller has been connected with the Westinghouse Air Brake organization for the past 22 years. He entered the company's service as a special apprentice immediately after his graduation as electrical engineer from the Michigan University in 1906. During the succeeding years he advanced rapidly from one position to another until he was appointed assistant chief engineer in 1926. His work has largely been devoted to air brake trials and tests of newly developed air brake improvements in their practical application.

The Line Material Company, South Milwaukee, Wis., manufacturer of electrical transmission and distribution specialties, has apponted the **A. & H. Corporation**, Chicago, as its representative in middle western territory.

A. C. Cronkrite, division sales manager for the **Universal Portland Cement Company**, Chicago, has been appointed assistant general sales manager. **Edward Quebbeman**, division sales manager for Illinois and Missouri, has been appointed western sales manager, with office at Chicago. **W. L. Greenly**, division sales manager at Duluth, Minn., has been transferred to Chicago district. **Harry A. Craig**, representative at Detroit, Mich., has been appointed division sales manager for Illinois and Missouri. **Earle D. McKay**, field engineer for the service bureau at Minneapolis, Minn., has been appointed division sales manager at Duluth.

J. E. Ham, railroad sales engineer of the **Hazard Manufacturing Company**, has resigned to become railroad sales engineer of the **Simplex Wire and Cable Company** with headquarters at Chicago.

Lewis Thomas has been appointed district sales manager at Chicago, for the **Q. and C. Company.**

Fred Johnson, district manager of the **Wagner Electric Company** with headquarters at St. Louis, has been appointed manager of the Los Angeles, Cal., office. **Alex Miltenberger**, Pacific Coast manager with headquarters at San Francisco has been transferred to St. Louis as branch manager of the St. Louis office.

Manning, Maxwell & Moore, Inc., New York, has purchased the **American Schaeffer & Budenberg Corporation** of Brooklyn, N. Y., and Worcester, Mass., from Ralph Jonas and associtcs. The newly acquired company, founded in 1851, manufactures industrial instruments. The business of the company will be co-ordinated with that of the **Consolidated Ashcroft Hancock Company, Inc.**, manufacturer of valves, indicating and recording instruments, which is owned by Manning, Maxwell & Moore. The operation of the Brooklyn and Worcester factories of American Schaeffer & Budenberg Corporation will at once be taken over by Manning, Maxwell & Moore.

L. E. Hasman has been appointed district sales manager of the **Q. & C. Company**, with headquarters at St. Louis, Mo.

Carl F. Weiblen, formerly manager at Cleveland, Ohio, for the **G. H. Williams Company**, Erie, Pa., has been appointed Chicago manager. Mr. Weiblen succeeds **R. B. Randall**, who has been appointed Pacific Coast manager for the **Link Belt Company**, with headquarters at San Francisco, Cal.

Louis Schlesinger, president of the **Bradley Washfountain Company**, Milwaukee, Wisconsin, has resigned following the acquisition of his interests by **H. A. Mullet**, who has been elected president. **G. W. Grossenbach** has been elected vice-president. **R. H. Weims** has been elected treasurer and **E. S. Wetherall** has been elected secretary.

The firm of **Rank & Goodell**, 906 Merchants National Bank building, St. Paul, Minn., manufacturers' agents, handling railway supplies, has been dissolved, and the business taken over by **George H. Goodell** and **Carl M. Hoppe** under the firm name of Goodell & Hoppe.

Items of Personal Interest

H. D. MacKenzie, master mechanic on the Canadian National at Campbellton, has retired under the pension regulations of that road. **Page Carlisle**, locomotive foreman at Moncton, N. B., will succeed Mr. MacKenzie as master mechanic at Campbellton.

H. B. Bowen, works manager of the Weston shops of the Canadian Pacific at Winnipeg, Man., has been promoted to assistant superintendent of motive power of the Western Lines, with headquarters in the same city. **J. Lee**, chief draftsman of the motive power department at Winnipeg, has been promoted to works manager of the Weston shops, succeeding Mr. Bowen. **A. Lupton**, general locomotive foreman at Winnipeg, has been promoted to assistant works manager of the Weston shops.

G. S. West, assistant master mechanic on the Pennsylvania, with headquarters at Meadows, N. J., has been promoted to master mechanic of the Conemaugh division, with headquarters at Pittsburgh, Pa.

Archibald Sturrock, who was formerly assistant superintendent of motive power of the Western lines of the Canadian Pacific, with headquarters at Winnipeg, Man., has been appointed master mechanic on the Esquimalt & Nanaimo, with headquarters at Victoria, B. C., succeeding **Walter Byrd** who has retired from active service.

New Publications

Books, Bulletins, Catalogues, Etc.

Some Reasons for Electrical Transmission on Self Propelled Rail Cars. The Westinghouse Electric & Mfg. Company has just issued a new publication (D. M. F.—5109) of the foregoing title.

The gas electric car has already established a place for itself in the transportation industry and the use of this equipment is rapidly being extended. However, the question is sometimes raised as to why it should be necessary to add electrical apparatus to the prime mover of such a car—why not use straight Diesel or gasoline engine drive?

Years ago the standard automotive type of transmission with gear shift and clutch release was suitable for self propelled cars, but with the necessary increase in engine horsepowers to meet operating requirements, difficulties were encountered in maintenance and low availability factor. Electric transmission solved the problem. In addition electric transmission has largely eliminated the burden on the operator of the car; it has much greater overall efficiency; the car speed is not determined by the engine speed; and with electrical transmission, the problem of double end and remote control is relatively simple.

There are many other inherent advantages of electrical transmission which have been elaborated on in this new publication, copies of which may be obtained from the nearest Westinghouse district office or from the Transportation Section, Advertising Department at East Pittsburgh.

The Historic Mohawk Valley, the only gap in the Appalachian chain from Georgia to Maine, is the subject of a handsome forty-eight page booklet just issued for free distribution by the New York Central Lines.

The stirring events which took place in the Mohawk Valley more than 150 years ago are fully described and the principal points of interest, including the old Glen-Saunders House erected in 1713 at Scotia; the Johnson House at Amsterdam; the Jan Mabie House at Rotterdam, the oldest house in this historic valley; the old Herkimer Home and Monument, as well as several others are beautifully illustrated.

Copy of this booklet may be had free of charge by addressing the Advertising Department, New York Central Lines, 466 Lexington Avenue, New York City.

Oil Electric Motive Power on the Canadian National. The Westinghouse Electric & Manufacturing Company has just released a new publication under the foregoing title.

The Canadian National Railway has had oil-electric cars equipped with Westinghouse-Beardmore engines in operation for the last three years and these have completed approximately 1,500,000 motor car miles. A detailed story, including performance data and statistics and cost of operation of these engines is surely of considerable interest to all railroad operators who may have on their system a place for such equipment. Copies may be obtained from the nearest Westinghouse district office or from the Transportation Section, Advertising Department at East Pittsburgh.

Railway Signaling Equipment. The Westinghouse Electric and Manufacturing Company announces a new 24 page pamphlet on electrical equipment for railway signaling. This new booklet, which is designated by the circular number 1787, covers a line of modern electrical equipment available for service in connection with the generation, transmission, control, protection, and maintenance of signal power.

The equipment listed includes frequency changers to change from 25 or 60 cycles to 100 cycles when 100 cycle power is to be used for train control, battery-charging motor generator sets designed for constant voltage from no load to full load, automatic switching equipment for controlling the signal power supply, disconnect switches, type S and SK transformers, autovalve lightning arrestors, choke coils, fuses, cutouts, porcelain insulators, materials used in wiring and insulating, and a full line of testing and recording instruments.

This booklet may be obtained from any Westinghouse office, or by writing to the Advertising Department, East Pittsburgh, Pa.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XLI | 136 Liberty Street, New York, November, 1928 | No. 11

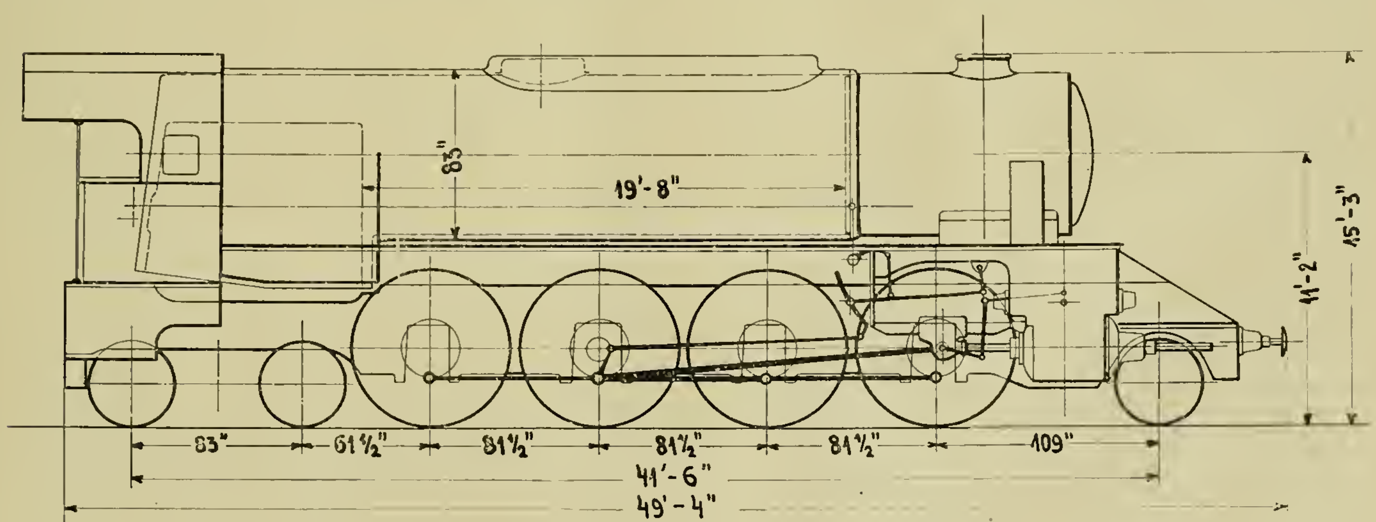
The Heaviest European Passenger Locomotive

Steam Power Versus Electrification in Austria

By Adolf Giesl-Gieslingen, M. E.

The Wiener Locomotivfabriks A-G, Vienna, Austria, have under construction what is claimed to be the heaviest and the most powerful high-speed steam passenger locomotive of Europe, which will be ready for service about the end of the year.

This fact is especially notable as the Austrian Federal Railways for which the new locomotive is being constructed, started an extensive electrification program immediately after the war and about 400 miles or nearly 10 per cent of their total mileage is now electrically operated. Although electric operation is successful in the mountainous districts of southern Austria, where grades between 2 and 3.4 per cent are encountered and a heavy international passenger traffic is moved, serious doubt arose as to the financial soundness of extending electrification beyond Salzburg towards Vienna. The maximum grade on this division is 1.1 per cent and the average daily traffic amounts to 14,000 tons in each direction. Investigations of the railroad company showed that, with the price of coal averaging $4.70 per ton of 12,200 B.t.u. value and investment interests at f.3 per cent, electrification of the 196 miles between Salzburg and Vienna would result in a yearly loss of 1,300,000 dollars when compared to steam operation. A great discussion arose in the public and engineering bodies when this result was published at the end of last year; while electricians claimed additional advantages of electric operation not visible in the figures given by the railroad, those advocating steam operation insisted that further reduction of operating and maintenance costs would be possible by the purchase of up-to-date steam power. In fact, the latest design of high-speed passenger locomotives on the line in question date back as far as 1909, (2-6-4 type series 210 and 310). The latest passenger engine for moderate speed was designed in 1915 and was later fitted with poppet valves (4-8-0 type series 113), while the latest freight locomotive is seven years old in design. The maximum axle load of all of these engines is limited to 33,000 lbs.; to provide for a boiler and machinery capable of developing from 1800 to 2000 horsepower continuously. Strength and durability especially of engine frame and working parts had to be sacrificed to some degree in spite of ad-



2-8-4 Type Locomotive of the Austrian Federal Railways, the Heaviest Passenger Engine in Europe mirable design. As a result of the abnormal depreciation during the world war and the rapidly increasing traffic demands, maintenance costs are excessive at the present time and amount to 1½ times the cost of fuel. There is no doubt that a greatly improved steam service could be provided at lower cost with the installation of new locomotives of more robust construction and greater power, eliminating overloading and wheel-slipping with their destructive effect on the machinery.

It was found after careful investigations, that with trains of 15 cars of an aggregate weight from 700 to 750 tons, a steam locomotive is able to exceed, on the greatest part of the line, the speed limit as governed by track conditions and curves. No noticeable increase could be obtained by electric operation.

Taking all this into account, the railroad decided to purchase three experimental locomotives which are to undergo severe tests in order to clarify the situation. The permanent way on the Austrian Western Railway between Vienna and Salzburg was already fit for an axle load of 40,000 lbs. for about 60 per cent of its length, the rest of the line was recently re-laid with 67-feet rails of 89 pounds per yard.

The two engines to be delivered first are designed for high speed service. One is being built as a two cylinder simple by the Floridsdore Works, the second as a three cylinder simple by the Sigl Works near Vienna. Details are interchangeable as far as possible.

The accompanying drawing shows the general arrangement and principal dimensions of the two cylinder engine.

Utmost care was taken to get maximum overall efficiency. Steam distribution is effected by a Lentz poppet valve gear, which has been highly perfected in Austria, especially by the Floridsdorf Works. A steam temperature of 720 degrees and over can therefore be used without any difficulties in lubrication. The feed water heater is of the Dabeg open type, the pumps are driven by the main engine as described in RAILWAY & LOCOMOTIVE ENGINEERING for August 1927. Special attention has been given to ample area in the live steam and exhaust passages and a novel front end arrangement is expected to reduce back pressure to a negligible amount. It will be of great interest to learn how the last named feature will work out, as the loss of power through excessive back pressure is getting more and more serious with increasing engine output.

An abnormally long main rod, 14 ft., keeps down the vertical thrust on the driving wheels. The machinery is designed for a maximum speed of 88 miles an hour while the normal running speed will be 69 miles. It was possible, through careful designing and the use of special materials to get the weight of the reciprocating parts down to only 1330 lbs.

The four wheel trailing truck permits the use of a simple, straight firebox. Its introduction on a tender engine took place in 1909 when Mr. Goelsdorf designed the first "inverted Pacific" or 2-6-4 type of locomotive for the Austrian State Railways. A total of 99 locomotives of this kind are doing excellent service. Since 1925, the four wheel trailer is rapidly gaining ground in the United States.

In addition to the above mentioned three cylinder locomotive of nearly identical design, a 2-10-4 type of tank engine is under construction, which will be the heaviest European locomotive with a single rigid frame. It is intended for heavy freight service.

Table of Dimensions, Weights, Etc., of 2-8-4 Type Locomotive of the Austrian State Railways

MACHINERY:	
Cylinders, diam. and stroke.	25.6 in. by 28.4 in.
Valve gear	Walschaerts
Valves	Double seat poppet type
Driving wheels, diameter	76.4 in.
Truck wheels, diameter	40.7 in.
BOILER:	
Type	Straight top
Steam pressure	213 lbs.
Diameter—first ring outside.	79 in.
Length between tube plates.	19 ft. 8 in.
Heating surface, fire box	204 sq. ft.
Heating surface, tubes and flues	2,850 sq. ft.
Heating surface, total evaporating	3,054 sq. ft.
Superheating surface	1,076 sq. ft.
Heating surface, total combined	4,130 sq. ft.
Grate area	50.8 sq. ft.
WEIGHTS IN WORKING ORDER:	
On drivers	156,500 lbs.
Total locomotive	261,900 lbs.
Total locomotive and tender.	390,000 lbs.
GENERAL DATA:	
Tractive power at 85 per cent boiler pressure	44,100 lbs.
Factor of adhesion	3,55

The report of the service tests of these new locomotives will be awaited with considerable interest, especially on account of their relation with the electrification program. These engines are said to be the "last word" in locomotives with conventional boiler pressure. The next step that the Austrian Railways are preparing, is the construction of a 2-8-4 type engine similar to that described above, but fitted with a Loeffler boiler for 1700 lbs. pressure and 880 degrees of steam temperature, and on which the Floridsdorf Works hold patents.

New Aerial Cableway in Africa

An aerial cableway to Table Mountain, South Africa, is nearing completion and will be opened early in 1929. Passenger cars are to glide up and down a giant cable 4,000 ft. long, suspended between Kloof Nek and the summit of the mountain. The cable hangs in a long gently curving line from the station on the summit to the station at the bottom. A restaurant is to be established on top of the mountain, on a site which overlooks the whole of the Southern Cape Peninsula as far as Cape of Good Hope.

Effects of Motor Trucks, Busses, and Aerial Transportation On Our Railways

By W. E. Symons

In four previous articles in the pages of RAILWAY AND LOCOMOTIVE ENGINEERING, the matter of aeroplanes, busses and motor trucks have been dealt with from various angles, the purport of all of which have been to show that while the railways have lost much passenger and some freight business, yet the wonderful growth of our country has been such, that all our combined transportation facilities have no more than measured up to requirements.

Recently one of our national writers sounded a pessimistic note of warning to our steam railways as to their future state, if they did not "wake up" and act on his advice at once and even should they heed the prophet's warning, they might after all be practically driven out of business by the new methods of transportation now coming into use.

So much has been said, and so many dark pictures painted as to the final "Sad Rites" to our steam railways, and these prophecies have been so often supported with the alleged "Simon Pure" facts as to the great losses in revenue that has (it is claimed by the pessimists) already reduced our railways to the verge of bankruptcy, that it seems quite pertinent to the subject to produce some truthful data on the subject.

Before going into details on the past and present, let us set up a hypothetical estimate of our probable future state as to population and the cost of transportation essential to our national life and activities.

Estimated population 1940	143,000,000
Revenue from various means of transportation	$10,000,000,000
Subdivided as follows:	
Railways	$8,000,000,000
Aerial transportation, motor busses, trucks, etc.	$2,000,000,000

Twelve years ago, or in 1916, total revenues were $3,472,642,000 as compared to $6,382,939,546 in 1926 or almost double. It might not be an extravagant guess to place the tentative figure for 1940 even higher than $10,000,000,000.

It is equally safe to say that, if the new forms of transportation, whether independently owned and operated, or when fostered by or owned by existing railway companies, succeed in developing their facilities and the volume of business handled during the next twelve years up to where they can and do actually handle business to the amount of $2,000,000,000 gross earnings, they will certainly have to be up and doing on a big scale.

In this connection it is worthy of note that the total revenue of our railways in 1890 was $1,051,877,000 and it required 23 years or until 1913 to add $2,000,000,000 to this sum, the total revenue in the latter year having been $3,125,136,000.

Possibly aerial transportation, motor busses, motor trucks, etc., with increased population may contribute to a result in twelve years what formerly required 23 years.

Regardless of the accuracy of all the above figures and tentative propositions, the fact remains that our railways have not been as "Hard Hit" by the bus as some of our pseudo experts would have us believe, and in all probability will not suffer much in the future.

That those in doubt may see and know, attention is invited to the following tabulation of cold facts that serve as a complete refutation of the claims of the great financial losses to our railways.

First, we will take passenger revenue, which it will be noted fell off from $1,031,563,016 in 1918 to $947,893,366 in 1927 or a shrinkage of $83,669,650, which is no small item. Before grieving too much over this one item, let us look at the freight revenue which in 1918 was $3,440,741,970, while in 1927 it was $4,630,713,035, or an increase of $1,189,961,065. An increase in freight revenue of more than 14 times the shrinkage in passenger business.

It seems not inappropriate to here comment on these figures, with the suggestion that if there is a railway executive who would not gladly trade $1.00 of passenger revenue for $14 of freight revenue and welcome the bargain, he is simply stupid. Furthermore, the writer is of the opinion that there "ain't no such animal."

Passing from the two items of passenger and freight revenue to the total income from operation which of course includes mail, express, etc., we find that for the year 1918 the amount was $4,880,953,480, while for 1927 it was $6,134,537,524, an increase of $1,253,584,044.

Again it might be construed by some that the loss of some eighty-three million dollars in passenger business was a blessing in disguise as some of this loss may have, and in all probability did, contribute indirectly to increased freight earnings.

It will be observed from the table that as passenger revenue fell off, freight revenue not only increased, but the following other items also increased:

(a) Net revenue increased from $898,885,283, in 1918 to $1,561,905,239 in 1927 or an increase of $673,019,956.

(b) Dividends paid, from $275,336,547 in 1918, to $411,581,093 in 1927 or an increase of $136,244,546, while the item of operating ratio decreased from 94.32% in 1920 to 74.54% in 1927.

From none of these figures is there evidence of our railways being in as great financial straits or danger, as is the reputation of those who make such wild guesses and false prophecies.

STATISTICAL TABULATION CLASS I RAILWAYS 1918—1927

	Items	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927
1	Mileage	233,203	233,808	234,668	234,419	234,825	235,185	235,500	236,380	236,626	237,758
2	Locomotives	63,889	64,983	64,746	64,949	64,512	65,327	65,358	63,974	62,761	61,317
3	Aver. trac. power	34,995	35,789	36,365	36,935	37,441	39,179	39,891	40,666	41,886	42,803
4	Net tons per train	656	675	708	651	676	713	715	744	772	778
5	Rev. per tr. mile frt.	$5.38	$6.20	$6.86	$7.37	$7.18	$7.18	$7.21	$7.41	$7.58	$7.59
6	Rev. per tr. mile pass.	$2.32	$2.56	$2.88	$2.51	$2.50	$2.56	$2.41	$2.37	$2.33	$2.23
7	Aver. pass. in train	79	85	83	61	66	67	64	62	61	60
8	Aver. journey miles	39.33	39.36	37.94	36.03	36.66	38.46	38.78	40.47	41.14	40.55
9	Pass. rev.	$1,031,563,016	$1,178,453,860	$1,286,613,273	$1,151,770,842	$1,074,108,060	$1,145,698,579	$1,075,039,219	$1,056,395,303	$1,041,816,167	$947,893,366
10	Frt. rev.	$3,440,741,970	$3,543,266,303	$4,317,440,080	$3,911,277,268	$3,992,441,331	$4,606,720,192	$4,333,585,195	$4,541,646,040	$4,797,780,122	$4,630,713,035
11	Rev. frt. car mile	$0.23	$0.25	$0.28	$0.31	$0.29	$0.28	$0.27	$0.27	$0.27	$0.27
12	Rev. per pass. car mile	$0.48	$0.52	$0.54	$0.51	$0.48	$0.49	$0.46	$0.43	$0.42	$0.39
13	Locomotives installed	2,803	2,062	1,017	1,330	1,226	4,360	2,786	1,600	1,882	1,536
14	Locomotives retired	977	999	1,254	1,130	1,682	3,746	2,529	2,873	3,101	2,976
15	Pass. cars installed	1,817	435	621	1,681	1,328	2,658	2,755	3,230	3,455	2,646
16	Pass. cars retired	1,051	670	885	929	1,286	2,360	2,295	3,569	3,309	3,606
17	Frt. cars installed	65,249	76,019	36,044	63,406	105,394	232,060	156,572	139,083	93,869	72,410
18	Frt. cars retired	56,024	43,274	75,197	69,245	126,471	213,789	118,590	128,573	103,152	95,753
19	Total opt. revenue	$4,880,953,480	$5,144,795,154	$6,178,438,459	$5,516,598,242	$5,559,092,708	$6,289,580,027	$5,921,496,325	$6,122,509,856	$6,382,939,546	$6,134,537,524
20	Total opt. expense	$3,982,068,197	$4,399,715,515	$5,827,591,146	$4,562,663,302	$4,414,522,334	$4,895,166,819	$4,507,885,037	$4,536,880,291	$4,669,336,736	$4,572,632,285
21	Net revenue	$898,885,283	$745,079,639	$850,847,313	$953,929,940	$1,144,570,374	$1,394,413,208	$1,413,611,288	$1,585,629,565	$1,713,602,810	$1,561,905,239
22	Dividends from income	$214,077,006	$213,960,125	$180,018,747	$182,433,297	$176,858,099	$195,029,636	$197,605,083	$202,453,923	$224,423,545	$240,282,406
23	Total div. paid	$275,336,547	$278,576,908	$271,731,669	$298,511,328	$271,573,751	$296,127,048	$320,429,767	$342,020,885	$399,243,960	$411,581,093
24	Opt. ratio, %	82.58	85.52	94.32	82.71	79.41	77.83	76.13	74.10	73.15	74.54

Returning again to the tabulation it is of interest to note that while revenue per passenger car mile fell off from $0.48 in 1918 to $0.39 in 1927, the revenue per freight car mile increased from $0.23 in 1918 to $0.27 in 1927, and that revenue per freight train mile increased from $5.38 in 1918 to $7.59 in 1927.

In the matter of equipment installed and retired, we again have evidence of a healthy growing concern, not only maintaining its physical property for present requirements, but making provisions for an increased volume of business in future.

The additions to and retirements of equipment for the years 1918 to 1927 are as follows:

	Locomotives		Passenger Cars		Freight Cars	
Year	Installed	Retired	Installed	Retired	Installed	Retired
1918	2,803	977	1,817	1,051	65,249	56,024
1919	2,062	999	435	670	76,019	43,274
1920	1,017	1,254	621	885	36,044	75,197
1921	1,330	1,130	1,681	929	63,406	69,245
1922	1,226	1,682	1,328	1,286	105,394	126,471
1923	4,360	3,746	2,658	2,360	232,060	213,789
1924	2,786	2,529	2,755	2,295	156,572	118,573
1925	1,600	2,873	3,230	3,569	139,083	128,573
1926	1,832	3,101	3,455	3,309	93,369	103,152
1927	1,536	2,976	2,646	3,606	72,410	95,753
Total	20,672	21,267	19,649	19,960	1,039,606	1,030,068
Total in service 1918	63,889		53,941		2,354,244	
Total in service 1927	61,317		53,804		2,354,134	
Decrease	2,572		Dec. 137		Dec. 110	

Tractive power of all locomotives in 1918 was = 2,223,246,296 lbs.
Tractive power of all locomotives in 1927 was = 2,605,345,530 lbs.

It will be noted that while the number of locomotives decreased 2,572 during the ten year period, yet through the retirement of 21,267 obsolete units, and the addition of 20,672 modern units, the total tractive force or pulling capacity has been increased by about 382,100,234 lbs. and this spells efficiency.

The slight decrease in the number of passenger cars (only 137) would not alone reflect the large drop in passenger revenue indicated, but the transformation from wooden to all steel modern cars, no doubt, accounts for the comparatively large number of installations and retirements.

In the matter of freight stock, while the installations and retirements are closely related, and the comparative number as of 1918 and 1927 is within 110 units it must be borne in mind that of the 1,030,068 cars retired, most of them were of wooden construction, or among the first steel cars built and that would now be obsolete. The 1,039,606 new cars installed are ultra modern in design and of greater capacity, as is evidenced by the fact that the average tonnage capacity in 1918 was 41.6 tons per unit. In 1927 it had been raised to 45.5 tons or an increase of about 4 tons on 2,354,134 cars, the sum total of which is about 9,400,000 tons increased capacity in the same or slightly decreased number of cars.

The transportation facilities of this country, railway, aerial, motor truck, motor cars and water routes will in a few years be taxed with providing transportation for 140,000,000 to 150,000,000 people, and that they will measure up to the task is no question.

The Class K-3 Locomotives of the New York Central

By Arthur Curran

The 4-6-4 type locomotives which have attracted so much attention on the New York Central have, for the moment, "filled the stage" to the exclusion of everything else. In point of fact, however, the road possesses a very fine "second line" of engines which are still doing excellent work and are capable of handling some of the best trains on the time-card.

I refer, of course, to Class K-3 and the various subclasses which were developed from it. These engines are of the Pacific type, and did all of the important fast work between the years 1911 and 1927. The earliest of them have 23½ x 26 inch cylinders; 79 inch drivers; and weight, without tender, of 269,000 lbs. As succeeding groups were placed in service, the weight rose, due to the introduction of various modifications and new details. In the course of time, changes were made even on the

Locomotive No. 3297 of the New York Central, a Class K3 Engine

earlier engines; but the basic design is much the same as it was nearly two decades ago.

In making the changes which, in the opinion of the management, seemed desirable, certain engines were selected for special attention; doubtless because they were particularly smart or generally "worth while." This will account for the variations to be found in the nature of the work done on the class as a whole. Moreover, very obvious consideration has been given to the matter of age in determining the extent of the work to be done on any engine of the class.

It may be mentioned here that, "for their inches," the K-3 engines were remarkably powerful and speedy.

"Getting down to cases," N. Y. C. No. 3297, shown in an accompanying photograph, exemplifies the policy referred to. She is fitted with a booster; and, in addition, has a nice large tender with high collar, and, hence, generous fuel-space. The arrangement of air-reservoirs and piping differs from the original practice on Class K-3; but that, of course, is purely a matter of taste.

No. 3297 is shown on a Buffalo-New York express, a class of work for which she is pre-eminently qualified.

Some engines of this general class—but without boosters and with the old small tenders—were handling Chicago trains recently, and may be doing so yet.

Railroad men know, of course, that certain engines of every batch are exceptionally good; a fact which, doubtless, accounts for the assignments alluded to.

At the time of the flood which cut the B. & A. line west of Springfield, Mass., the Chicago-Boston trains had to be routed for part of their detour over the Hudson River Division of the N. Y. C. These trains were handled by K-3 engines on very fast schedules, and made up a large amount of lost time arising from the long and roundabout route. Inasmuch as the trains were very heavy and the running was done under unusual conditions, the locomotives are entitled to the highest praise.

Interest in the "Horatio Allen" and the "John B. Jervis" of the Delaware & Hudson, together with the fact that for many years the road used many engines of the "Mother Hubbard" type, may be taken as the reason why some people may not know that locomotives of conventional design are owned by this historic company.

Reference to the photograph of D. & H. No. 601 on an Albany-Binghamton train will demonstrate that the Pacific type is favored by this road on important runs. The design incorporates the Wootten firebox, which is suited to the grade of coal which is used, and drivers of moderate diameter, which were specified on account of the profile of the road and the nature of the traffic to be handled.

Incidentally, the road owns several classes of Consolidation type engines; aside from the amazing machines which were designed by Mr. Muhlfeld. These classes are of conventional style, though fitted with Wootten fireboxes.

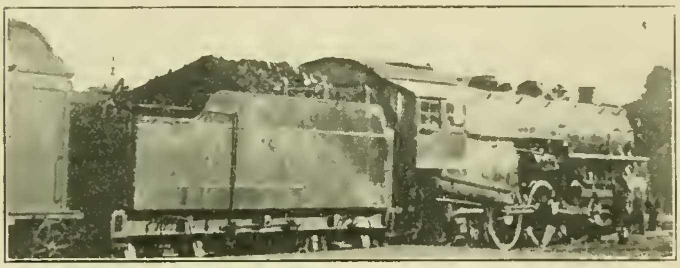
Earlier Consolidations have the cab saddled over the boiler barrel, in the traditional manner long prevalent on the "hard coal roads."

In this connection, it may be mentioned that such engines certainly gave more power than any class having the old, long, narrow grate. Of course, it is a good thing that the construction of "Mother Hubbard" engines is no longer legal; but truth compels the admission that such engines did some very fine work.

During a blizzard, which occurred some years ago, the D. & H. was the only road that could get in or out of a certain city in which I was sojourning at the time. The engine—a "Mother Hubbard" of the 4-6-0 type—came in with a passenger train, and went out with it again. She was the only engine, on three roads, that "turned a wheel" for twenty-four hours! I can hear, in memory, the dulcet tones of her Schenectady bell above the roar of the storm, and her angry, belligerent exhausts as she fought her way in triumph!

It was a great day for the Wootten firebox! I suppose that she had about 80 square feet of grate. Anyhow, in her argument with the blizzard, the storm came out "second best."

The modern practice of providing ample grate area insures a steaming capacity that would be impossible otherwise. Originally designed to burn anthracite, such grates have been found most satisfactory in the use of



Pacific Type Locomotive No. 601 of the Delaware & Hudson

the cheaper grades of fuel, and thus have saved the railroads vast sums of money while performing in a superior manner.

Certainly, the railroads owe much to the men who proved that the narrow grate was a handicap to proper development of motive power, and that the wide grate was the key to future success.

Purchases for Five Years Total 7½ Billion

Purchases of fuel, materials and supplies made directly by the railroads of this country in 1927 totaled $1,395,-928,000, according to a report compiled by the Bureau of Railway Economics.

This figure as to the amount of purchases made by the railroads during the past year covers only those items that were directly bought and paid for by railroad companies. In addition, the railroads are indirect purchasers of many commodities, large quantities of which go into railway equipment and into new construction that is contracted for under lump-sum agreements and not classified under the head of direct purchases.

Total purchases for the year 1927, said the report represented a decrease of $163,104,000 to 10.5 per cent under 1926. Railway traffic was less in 1927 than in 1926 by some 3 to 5 per cent, varying as between the freight and passenger services Railway revenues in 1927 declined 4 per cent and operating expenses decreased 3 per cent. These reductions supply some of the reasons for the decline in railway purchases during the past year.

Railroads Consume 25% of Soft Coal Production

That the railways are among the largest buyers of the nation's production of the principal materials is shown by the fact that in 1927 they purchased 25 per cent of the bituminous coal output, approximately 25 per cent both directly and indirectly of the timber cut, and 19 per cent of the total production of iron and steel products, steel rail alone amounting to approximately 87 per cent of the total rail production.

In the past five years the railroads have expended nearly seven and a half billions of dollars for fuel, materials and supplies, distributed among the five years as follows:

1923	$1,738,703,000
1924	1,343,055,000
1925	1,392,043,000
1926	1,559,032,000
1927	1,395,928,000
Total 5 years	$7,428,761,000

Total expenditures for fuel in 1927 amounted to $438,-821,000, a reduction of 7.3 per cent under 1926. Of the total amount $346,814,000 was expended in 1927 for bituminous coal, total purchases having amounted to 130,-190,000 tons.

More Cross Ties Bought Last Year

Direct purchases of forest products in 1927 amounted to $175,729,000, a decrease of 5.7 per cent under 1926. Cross tie purchases in 1927 amounted to $108,215,000, there having been an increase of 3.6 per cent in the number of ties purchased during the past year compared with 1926 and an increase of 7.0 per cent in the cost. More cross ties were purchased in 1927, than in any year since 1924. In addition, large expenditures were made for switch and bridge ties and for timber and lumber purchases.

Purchases of steel rail in 1927 totaled $101,567,000, representing 2,278,000 gross tons. With the exception of 1926, the 1927 gross tons of rail purchases were greater than in any recent year.

It is estimated that the railways in 1927 absorbed 6,125,000 tons of steel while building and construction accounted for 7,050,000 tons.

Increased Use of Heavier Rails

During recent years, heavier steel rails have been coming more and more into use to meet conditions imposed by heavier and denser traffic. Rails of 100-pound section and over rolled in 1927 were more than two-thirds of the year's production of all rails. In 1926, the corresponding proportion was 61 per cent.

The outlay for cement during 1927 amounted to $6,811,000, a decrease of 16.7 per cent compared with the year before.

The total purchases of lubricating oils and grease, boiler compound and waste for the year 1927 was $23,-280,000, a decrease of 13.8 per cent under 1926.

For the various non-ferrous metal products needed in railway operation, such as brass, copper, zinc and lead, the railways spent $55,668,000 in 1927 or 8.8 per cent less than in 1926.

Approximately 28,430,000 cubic yards of ballast were purchased in 1927 by the railways, an increase of 11.8 per cent over 1926. The total cost in 1927 was $23,965,000.

Committee Reports to the Mechanical Division of the American Railway Association

Exhaust Steam Injectors and Exhaust Steam Feed Water Heaters

A sub-committee of four members of the committee reported as follows:—The committee on exhaust steam injectors and exhaust steam feed water heaters has continued the investigation on development of this equipment, and can offer only a progress report at this time. Looking into the status of the device, we find one manufacturer, as of March 26, 1928, has 220 exhaust steam injectors in service, and an order for 38 additional pending. Although we were in communication with the other manufacturer, and its statement of equipment in service and on order has been promised but not yet received, it could not be included in this report.

Your committee has found that one of the principal drawbacks in the development and application of the exhaust steam injector in this country is due to the complication of manual operation as compared with the common injectors. Efforts are being made by the manufacturers toward simplifying the manual operation by the introduction of automatic control from exhaust to live steam. This will have a tendency to popularize the use of the exhaust steam injector. It will be appreciated that the exhaust steam injector is strongly competitive with the straight feed water heater, particularly as regards the percentage of economy in fuel and water, and while in general the exhaust steam injector represents lower priced installation, the modern superpower locomotives require that we take advantage of the highest attainable economies to be derived from feed water heating. It must be remembered that the development in feed water heaters has not been standing still. We allude to the trend toward centrifugal feed water pump, which bids fair to replace the reciprocating steam pump very largely in the near future. It is the opinion of your committee, however, that there seems to be a legitimate field for a fully developed, thoroughly reliable exhaust steam injector with simplified manual control, in the field of moderate sized and smaller sized existing power, where it is desirable to obtain some economies in fuel and water at a comparatively low investment charge. When we consider the popularity of the exhaust steam injector on English roads, and the extent to which it is being used there, the committee feels there is an opportunity awaiting the exhaust steam injector on the American roads when it is sufficiently developed to meet the operating conditions in this country.

High Boiler Pressures

The report of a sub-committee on advantages and disadvantages of boiler pressures higher than 200 lb. was the practical limit of high pressure in radial stayed boilers, but the Delaware and Hudson Co. has in service two locomotives, with radial stayed boilers, carrying pressures of 275 and 300 lb. respectively, while a third using 325 lb. is contemplated. This road also has two locomotives with water tube fireboxes, viz., the Horatio Allen, using 350 lb. pressure, and the John B. Jervis, using 400 lb. pressure. During the four months in which the locomotive with the radial stayed boiler carrying 300 lb. pressure has been in service, high temperature conditions, reaching 800 degrees F. at the steam chests, have existed at times, but no serious effects have been noted, and no packing renewals have been required. Several railways are interested in the development of equipment using higher boiler pressure than the conventional. The Atchison, Topeka and Santa Fe is working on radial stayed boilers to carry 275 lb. The Canadian National Ry. has 40 locomotives, and its subsidiary, the Grand Trunk Western Lines, has 12, in which use is made of high tensile strength silicon steel, with average tensile strength 76,800 lb., and yield point of about 46,100 lb., for the boilers, the use of this steel having permitted an increase in the boiler pressure of from 200 to 250 lb., with but little change in design, size or weight of boilers. The Canadian Pacific has 44 locomotives using 250 lb. boiler pressure, in which the boilers are built of nickel steel, with average tensile strength of 76,700 lb. and yield point of 59,200 lb. This represents a 29 per cent gain in strength over the usual carbon steel.

While Europeans still continue their development with ultra-high pressures, the prevailing tendency in this country is to remain below 400-lb. pressure, and not depart far from conventional design. This conservative attitude seems preferable at this time, as it is a relatively simple matter, even with conventional cylinder arrangements, to obtain considerable added economy by taking advantage of the highest possible pressures in radial stayed boilers, coupled with increased superheat up to 800° F. The highest pressure, it seems evident, must remain below 400 lb., as higher pressures will necessitate the use of water tube boilers or, to the extent that pressures are increased, freak constructions.

As pressures go up, it is obviously essential that advantage be taken of higher cut-offs, this being, however, difficult to do in a satisfactory manner with the present types of valve gears. This might be accomplished with cam-actuated poppet valves, as the intakes may be adjusted to give a long period of full port opening with very early cutoff without affecting the long full exhaust port opening. The Caprotti valve gear, which is an outstanding example of that type of gear, fills a gap as it makes practical the expansion of relative high pressures in a single stage without over-compression. It is undesirable to introduce the complications of compounding except as it becomes imperative in connection with the use of ultra-high pressures.

Another example of the use of poppet valves is the Buchli Locomotive, wherein single seated poppet inlet valves are used in uniflow type of cylinders. The cutoff is controlled by cams of various shapes, or lengths of cam heel, the shaft being arranged to slide laterally to the position selected. In this locomotive the boiler pressure of 850 lb. is expanded in a single stage and the exhaust released to the atmosphere. Some excellent operating results have been obtained with this locomotive. In this operation, the feed water is brought to a very high temperature in the preheater and economizer, and practically all foreign matter is precipitated before the water enters the water-tube boiler. These preheater and economizer units are protected from direct action of the flames, and so built that they may be readily cleaned.

This locomotive is of special interest at this time, as it represents the simplest possible conception of an ultra-high pressure locomotive. Both boiler and engine are relatively simple in design, and the necessary auxiliaries are reduced to a minimum. Weight and cost are approximately that of an ordinary high grade locomotive. The engine and other operating parts are accessible and simple to service. Operation of the locomotive is no more complex than the conventional type. Vibration is reduced to a minimum, and the torque at the drives is uniform.

Data for the Buchli locomotive and a comparative one of conventional form are as follows:

	Conventional	Buchli
Boiler pressure	170 lb.	850 lb.
Heating surface, sq. ft.	1290	1040
Superheater surface, sq. ft.	346	215
Water capacity, boiler, imp. gals.	1080	594
Number of cylinders	2	3
Diameter of cylinders	21¼ in.	8½ in.
Stroke of pistons	23⅝ in.	13¾ in.
Ratio of gear drive	No gears	2½ to 1
Diameter of wheels	60 in.	69 in.
Maximum speed, m.p.h.	46½	50
Wt. in working order, tons	90.8	75

Comparative tests were made of these two locomotives on runs out of Winterhur, Switzerland, under approximately the same operating conditions. Detail figures are not available, but Dr. Buchli states that a coal economy of 35 to 40 per cent and water economy of 47 to 55 per cent was obtained in favor of this type of locomotive. It is unlikely, however, that such large economies would be realized, as compared to the large efficient locomotives in use on the better equipped American railways.

To one constructive suggestion that your committee desires to offer, is the fact that for roads wishing to avail themselves of further economy in locomotive operation without departing materially from conventional practices, there exists the opportunity, previously referred to, for deriving substantial economies by availing themselves of the upper limits of boiler pressures possible in properly designed radial-stayed boilers in conjunction with considerably higher superheat than is now in general use. With this combination of higher pressure and higher superheat, it is still practical to use the conventional two and three-cylinder single expansion arrangement. This is not intended to reflect in any way upon the interesting experiments that are being made with higher pressures, ultra-pressures and water tube boilers, but simply to give a thought to those who still desire to adhere to conventional practice.

Oil-Electric Locomotive Development

The year 1927 has seen the entry of two new oil engines into the oil-electrical locomotive field, and one new type of oil-electric storage battery locomotive. The first two engines consist of the Beardmore, as built by Westinghouse Electric & Manufacturing Co., and the McIntosh-Seymour oil engine as built by the McIntosh-Seymour Corporation. The Beardmore engine is essentially the same construction as those built by the William Beardmore Co., London, England, and is briefly a 4-cycle solid injection, 6 cylinders 8¼ x 12 in., and develops 300 h.p. at 750 r.p.m. The McIntosh-Seymour engine is a 4-cycle, air injection, having 12 cylinders 8 x 9½ in., and develops 300 h.p. at 500 r.p.m. Additional physical characteristics of these engines are included in the accompanying table 1.

An appendix to the report states as follows:—"The Westinghouse Electric & Mfg. Co. has entered the oil-electric railway field with the Beardmore oil engine. These engines are essentially the same construction as those built by William Beardmore Co., London, England. Their physical characteristics have been added to table 1. These units were delivered to the Long Island Rd. in April, 1928. The electric transmission and oil engines were built by Westinghouse Electric & Mfg. Co., and the mechanical portion was built by Baldwin Locomotive Works."

The McIntosh & Seymour Corporation built, jointly, with Brill Car Co., and General Electric Co., a new oil-electric switching locomotive for Lehigh Valley Rd. for service at their 149th Street yards. As noted in table 1, this engine is an air injection fuel type, having 12 cylinders arranged in a V, similar to the well-known twin-six arrangement used in automotive practice, and was delivered to the railway during the latter part of 1927.

The new type oil-electric battery locomotive built jointly by Ingersoll-Rand General Electric Co., and the Electric Storage Battery Co., at the American Locomotive Co.'s plant, at Schenectady, N. Y., is designed to operate from internal power furnished by the battery alone, or from power furnished from the storage battery and oil-engine generator together. It can also run from external power furnished by the third rail or overhead wire in electrified districts. The oil engine and generator is a 300 h.p. unit, similar to ones furnished by the Ingersoll-Rand in its 60-ton switcher. This locomotive, listed in table 1 of 1927 annual report, was delivered to the New York Central Rd. early in 1928. It is powered with the Ingersoll-Rand oil engine, and a 680 ampere hour Exide-Ironclad storage battery furnished by Electric Storage Battery Co. The electric transmission and generator was furnished by General Electric Co., and the mechanical portion built and the locomotive equipped by American Locomotive Co., at its Schenectady plant. This locomotive is primarily intended for operation in the freight yards on the west side of New York City. Since it is intended that the locomotive will be used mainly in yards not electrified, the 300 h.p. oil engine direct connected to a 200 k.w. generator is provided for charging the battery. The generator is designed so that if it is run at the same time that power is being used by the traction motors, it will divide the load with the storage battery under periods of heavy output without overloading the engine, and will return automatically to charging the battery as soon as the load has decreased. The locomotive can be operated alone, and it is also supplied with third rail shoes and an overhead collector. This permits the engine and battery to be disconnected from the traction motors when operating in electrified districts. The foregoing shows the flexibility of operation of this locomotive, which is the first of its kind to be placed in service. It has not been in service long enough to determine whether or not it can meet all the requirements of the west side yards, but it has evident potentialities. Such a locomotive may not find wide application, but it appears to be admirably suited to meet switching requirements in localities where the steam locomotive is looked upon with disfavor.

None of the above units have been in service long enough to determine operating or maintenance cost, but it is hoped that sufficient information will be obtained during the coming year to enable it to be presented in next year's report. The oil-electric passenger and freight locomotives for the New York Central Rd., and the Pennsylvania switchers, listed in table 1 of the 1926 report as being under construction, are expected to be delivered sometime during the early summer of 1929.

The committee recommended that its report with appendices be received as information, that a study of oil-electric locomotive development be continued, with a collection of operating information and data, and, if practicable, an analysis of operating costs and general performance.

Table 1, giving specifications of oil-electric locomotives in service, is based on similar tables accompanying the 1926 and 1927 reports, with information added to bring the compilation up to date. Table 2 is a concise statement of oil-electric locomotives in service, or on order, in the United States, and table 3 gives the general dimensions of specially designed oil-engined locomotives on order, or delivered recently.

TABLE 1—TABULATION AND SPECIFICATIONS OF OIL-ELECTRIC LOCOMOTIVES

No.	Loco. Builder	Owner	Engine Builder	Electric Builder	H.p.	Total Weight Loco.	Weight Per H.p. Eng. Only	Weight Per H.p. Total	Cylinders No. and Size	Cycle	Fuel Injection	Engine R.p.m.	Wheel Arrangement	Date in Service
1	A.L.Co.	C.R.R.N.J.	I.R.	G.E.	300	120M	56.7	400	6—10 x 12	4	Solid	600	4-4	1925
1	"	B.&O.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1925
1	"	L.V.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1926
1	"	C.&N.W.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1926
1	"	Erie	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1926
1	"	Reading	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1926
1	"	D.L.&W.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1926
1	"	C.&N.W.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1926
1	"	Utah Cop.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1926
1	"	I-R.Co.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1926
1	Brill	L.V.	Mc.S.	"	300	152M	90.0	507	12—8 x 9½	4	Air	500	4-4	1927
1	A.L.Co.	L.I.	I.R.	"	600	200M	56.7	333	12—10 x 12	4	Solid	600	4-4	1925
1	"	Red Riv.	"	"	600	200M	56.7	333	12—10 x 12	4	"	600	4-4	1926
1	"	G.N.	"	"	600	200M	56.7	333	12—10 x 12	4	"	600	4-4	1926
1	"	L.I.	"	"	600	200M	56.7	333	12—10 x 12	4	"	600	4-4	1927
1	"	N.Y.C.	"	"	300	257M	56.7	*833	6—10 x 12	4	"	600	4-4	1928
1	"	N.Y.C.	"	"	750	291M	60.0	390	6—14¾ x 16	4	"	500	4-8-4	U.C.
1	"	N.Y.C.	Mc.S.	"	900	348M	91.0	397	12—14 x 18	4	Air	300	4-8-4	U.C.
1	Pa. Rd.	P.R.	Bess.	West.	500	130M	40.0	260	8—8½ x 12	4	Solid	800	0-4-0	U.C.
2	Baldwin	L.I.	West.	"	300	90M	34.0	300	6—8¼ x 12	4	"	750	0-4-0	1928
2	A.L.Co.	Erie	I.R.	G.E.	600	200M	56.7	333	12—10 x 12	4	"	600	4-4	1927
1	"	C.&N.W.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1927
1	"	Reading	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1928
1	"	Am.R.Ml.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	1928
1	"	Am.R.Ml.	"	"	600	200M	56.7	333	12—10 x 12	4	"	600	4-4	U.C.
1	"	L.I.	"	"	600	200M	56.7	333	12—10 x 12	4	"	600	4-4	U.C.
1	"	Donn.St.L.	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	U.C.
5	"	Stock	"	"	300	120M	56.7	400	6—10 x 12	4	"	600	4-4	U.C.

Ingersoll-Rand 600 h.p. locomotive consists of 2-300 H.P. units. *Oil-electric storage battery engine. Note—U.C. denotes under construction.

Table 2.—Electric Locomotives in United States, in service or on order

No. of units	Unit h.p.	Total h.p.	Average h.p.
22	300	6,600	...
3	500	1,500	...
8	600	4,800	...
1	750	750	...
1	900	900	...
35		14,550	416

Back Pressure and Initial Pressure Gauges, and Cut-off Control

The report stated as follows:—1. Single pointer type gauges to indicate back pressure only. 2. Duplex type gauges, one hand of which indicates the steam chest pressure and the other the back pressure. 3. Duplex type gauges, one hand of which indicates the speed of the locomotive in miles per hour and the other the position of the cut-off. 4. Back pressure cut-off control, which is a device for automatically regulating the cut-off by means of the back pressure in the cylinder exhaust cavities. Gauges which indicate both the steam chest and the back pressure are of several styles, as follows:—(a) Gauges having two hands and one dial, the dial having two scales, the outer scale with graduations suitable for the steam chest pressure, and the inner one with graduations suitable for the range of back pressure.

(b) Gauges having one hand and two dials, the outer dial being stationary and having graduations suitable for the steam chest pressure and the inner dial rotating to show the back pressure indicated by a fixed pointer. (c) Gauges having two hands and one dial, the dial being graduated for steam chest pressure. With this gauge when there is no back pressure, the two hands are together, or coincide as to location. As the back pressure increases, the hands separate, the extent of the separation indicating the amount of back pressure.

TABLE 3—GENERAL DIMENSIONS OF SPECIALLY DESIGNED OIL-ENGINED LOCOMOTIVES

	Railways		
	Pennsylvania	N. Y. C.	Long Island
Total weight lb.	130,000	257,000	*180,000
Length over coupler pulling faces	26 ft. 10 in.	46 ft. 8 in.	25 ft. 6 in.
Rigid wheel base	10 ft.	8 ft. 3 in.	8 ft.
Height	14 ft. $8\frac{7}{16}$ in.	14 ft. 8 in.	11 ft. 11 in.
Width	10 ft. 6 in.	10 ft. 2 in.	10 ft. 2 in.
Tractive effort	40,000 lb.	60,000 lb.	43,000 lb.
Generator	West. No. 476, 330 k.w. at 800 r.p.m.	G.E. No. DT-502, 200 k.w. at 600 r.p.m.	West. No. 477, 200 k.w. at 750 r.p.m.
Motors	2-West. No. 355, 300 h.p., each.	4-G.E. No. 286, 300 h.p., each.	2-West. No. 308H, 215 h.p. each.
Gearing	16-76	17-72	16-66
Oil-engine	Bessemer	Ingersoll-Rand	Beardmore
Oil-engine h.p.	500	300	300
Weight battery	....	34,300 lb.	....
Type	....	MVA-41	....
Number cells	....	218	....
Ampere-hour at 6 hr. rate.	....	680	....

*Weight per single 0-4-0 unit—90,000 lb.
Total weight of locomotive (two units giving an 0-4-0 plus 0-4-0 wheel arrangement)—180,000 lb.

Gauges which indicate the speed in miles per hour and the position of the cut-off, require a mechanism driven from one of the wheels to give the speed indication, and another mechanism connected to the reverse gear to indicate the position of the cut-off. The locomotive back pressure cut-off control is a somewhat more complicated device, whereby the cut-off is regulated automatically by the back pressure to an economical position. Each of these devices has for its object the more economical operation of the locomotive, and for this reason its development should be encouraged. All of them appear to be more or less in the experimental stage. Many difficulties have been encountered and changes are constantly being made.

If the railways will select the types of apparatus which seem most likely to meet their service requirements and try them, their experience will help in developing these devices, which give considerable promise of effecting more economical locomotive operation.

Brakes and Brake Equipment Committee's Report

The brakes and brake equipment committee, of which G. H. Wood, Supervisor of Air Brakes, Atchison, Topeka and Santa Fe Ry., was chairman, and of which W. H. Clegg, Chief Inspector, Air Brake and Car Heating Equipment, Canadian National Ry., and H. A. Clark, General Air Brake Inspector, Minneapolis, St. Paul and Sault Ste Marie Ry., were members, presented a report, the chief feature of which was an appendix containing a thorough analysis of paper entitled "Standardization of the braking power of freight cars," which was presented at the Air Brake Association's 1927 annual meeting by F. K. Vial Vice President and Chief Engineer, Griffin Wheel Co. This analysis was prepared by an A. R. A. Mechanical Division-Airbrake Association joint committee, of which F. H. Parke was chairman, and of which Messrs. Wood, Clegg and Clark were members, and was accompanied by the following recommendations:—1. That no variation in the braking ratio be allowed due to the difference in the empty weights or carrying capacity of cars, since uniformity is obtained to the maximum degree when the empty cars all have the same braking ratio. 2. That no differential be adopted at present in braking ratios due to the materials used in wheels or brake shoes, nor in the future until definite differences in the frictional characteristics of those materials are determined. And then, when such differences are determined, no reduction in the braking ratio of any car below that now standard should be permitted, the differential operating only to bring the lower frictional materials up to the standard of the highest. 3. We recommend to the A. R. A. that it be made standard practice for cars in general interchange to be supplied with a foundation brake gear plate permanently attached to the car underframe near the brake cylinder in a conspicuous and accessible location, which will contain in an indestructible form the necessary information to enable correct replacement of both body and truck levers. 4. That, as soon as this plate is applied, the car inspectors at all repair points be instructed to check up the brake gear on all cars on the repair track by reference to this plate, at the same time that the brake is tested, and substitute correct levers whenever wrong ones are found. Also that the A. R. A. make suitable addition to the rules of interchange to indicate the proper billing for this work on foreign cars. 5. That a vigorous campaign be inaugurated as soon as possible to correct the appallingly chaotic condition of leverage which apparently exists, by bringing the braking ratio of every car within the range between 57.5 per cent minimum and 62.5 per cent maximum with 50 pounds cylinder pressure. The analysis concluded with the statement that the wonderful improvement that has recently been achieved in the condition at the air operating devices should be followed by an equally effective improvement in the maintenance of foundation brake gear.

The committee's report proper dealt with the application of triple valve gaskets braking power on refrigerator cars, and various recommendations, the latter dealing with the following matters: channel caliper gauge; spring type retaining valves; brake leverage ratio for passenger cars; tolerances for camber of brake beams; triple valve test racks; bushing triple valve exhaust ports; steam and air connections for passenger cars; restoration of pages removed from the manual of standard and recommended practice; air brake hose couplings and gauges; requirements for equipping new cars with centrifugal dirt collectors, and the cleaning, lubricating and testing of air brakes on passenger equipment cars.

Braking Power on Refrigerator Cars

In discussing this matter, the committee referred to Mr. Vial's paper, and after the presentation of numerous figures, said: "The present A. R. A. standard braking ratio of freight equipment is not being maintained on a very large number of cars in general interchange. In our judgment, this condition of brake gear, more than any other one cause, is responsible for a large percentage of damaged wheels, brake gear failures, bent brake beams, burned brake shoes and heads, break-in-twos, and bad slack action in freight service. There is no use in talking about adopting a new standard for braking ratio until we can find out what will happen when the present standard is properly maintained." In view of this condition, the committee recommended:—1. That no variation in the braking ratio be allowed, due to the differences in the empty weights or carrying capacity of cars, since uniformity is obtained to the maximum degree when the empty cars all have the same braking ratio. 2. That no differential be adopted at present in braking ratios due to the materials used in wheels or brake shoes, nor in the future until definite constant differences in the frictional characteristics of those materials are determined. When such differences are determined, no reduction in the braking ratio of any car below that new standard should be permitted, the differential operating only to bring the lower frictional materials up to the standard of the highest. 3. That a metallic plate be made a standard part of every car, fastened to the underframe in an accessible place, preferably near the brake cylinder, which shall contain in an indestructible form the proper dimensions of levers for both body and truck brake gear. When an approved form of bade plate is applied to any car, checking of the levers to see that they conform with the standard dimensions be made a part of the rules in effect on all railways in governing annual repairs to brakes on freight cars, and, if wrong levers are found, that they be replaced with levers conforming to the dimensions shown on the badge plate.

Triple Valve Gaskets

The committee stated that the application of two or more triple valve gaskets between triple valves and reservoirs on freight cars had been brought to its attention, and said: "The committee is of the opinion that the necessity for more than one gasket will be obviated by ensuring that properly dimensioned studs are used in each instance. Where difficulty is experienced in making a tight joint, the studs should be checked to ensure that the threaded portion will permit of the triple valve being drawn tightly to its seat with the application of a standard gasket. The committee strongly urges careful attention to this feature as a means of improving the service, and effecting economy through the conservation of material."

Spring Type Retaining Valves

The committee referred to its report at the 1927 meeting, in Montreal, in which a modification of the specification for the A. R. A. duplex spring type retaining valve was recommended. A type of cap has been developed, which can be substituted for the present caps, and in which provision is made for the prevention of spring distortion. The committee stated that the air brake companies will include the new type of cap with new valves, and will supply it for repairs to existing valves at a slight additional cost. A drawing of the valve, showing, in section, the modification in the cap, spring and valve assembly, is given in the accompanying illustration. The modification consists of a redesign of the valve 4 in each cap nut 21, doing away with the guide at the bottom, and addition a recess at the top of the valve stem to provide for the ⅛ in. pin 22, which prevents removal of either the valve or spring without drilling out the pin. With this construction, there is also a greater certainty of a good joint being obtained and maintained in the closing action of the valve than with the present design, thereby improving the valve from a leakage standpoint. The pin 22 does not extend all the way through the cap, but only to a depth sufficient to hold the valve in place. The new caps complete are perfectly interchangeable with the old so that all spring type valves in service can be changed to incorporate the improved spring cap and feature if desired. The older spring type valves in service and which do not conform to the present requirements by applying proper chokes to the valve body. The committee stated: "We are under the impression that the trouble experienced with the present caps, on account of springs being distorted, makes this improved cap highly desirable, and would strongly recommend its general use in the maintenance of retaining valves now in service."

Brake Leverage Ratio for Passenger Cars

The committee said: "It is important that the brake leverage ratio be maintained within certain limits, in order to avoid undesirable false piston travel, and preventing the evils resulting therefrom. It has developed that there is a tendency to use leverage ratios in excess of that which is good practice. The committee, therefore, recommends as recommended practice the total brake leverage ratio for passenger cars having 6 wheel trucks shall not exceed 8 to 1 and 9 to 1, respectively, with single shoe and clasp type of truck brake gear."

Bushing Triple Valve Exhaust Ports

A question having been raised with reference to bushing exhaust ports in trip valve bodies, the committee recommended that exhaust ports requiring regushing due to damaged threads or otherwise be increased not to exceed ½ in. pipe size.

Centrifugal Dirt Collectors

During the past year, the committee recommended to the arbitration committee that a rule be inserted in the interchange rules providing that all cars built after date to be specified by the arbitration committee must be equipped with centrifugal dirt collectors. The arbitration committee suggested that if the brakes and brake equipment committee considered it desirable to require the application of dirt collectors on new cars, it should recommend a specific date in its report. The committee, therefore, recommended that all cars built on or after June 1, 1929, be equipped with centrifugal dirt collectors.

The committee recommended that A. R. A. rule 1 of the passenger car code be changed to read as follows: "Each railway company shall give to foreign cars, while on its line, the same care as to inspection, oiling, packing, and the cleaning, lubricating, testing and adjustment of brakes, that it gives to its own cars, except in case of cars on which work is done under special agreement existing between the company owning the cars and the road operating same."

Wheels Committee's Report

The wheels committee, of which C. T. Ripley, Chief Mechanical Engineer, Atchison, Topeka and Sante Fe Ry., was chairman, presented, along with its report, a proposed wheel and axle manual, 187 pages, profusely illustrated, on which a great deal of work has been expended. In 1925, the committee presented a tentative draft of such a manual, but the issue of the final manual had since been held up, due to tests and inspections made in connection with the revision of the section dealing with wrought steel wheel defects, but this particular section was cleared up during the past year. In addition to the steel wheel section, the remaining portions of the manual were entirely rewritten and much new material was added.

The first part of the committee's report was devoted to a complete new specification for cast iron wheels, the committee recommending that it be adopted as recommended practice of the Association.

A considerable part of the report was devoted to wheel gauges. In regard to the wheel mounting gauge, it said: "If the reinforced flange wheel is adopted by the Association, as recommended in the first section of this report, the Association's standard wheel mounting gauge will have to be suitable for this type of wheel. Last year the Association adopted a mounting gauge for reinforced flange wheels, and there are, therefore, two standard mounting gauges. Experience with this new wheel mounting gauge appears to have been entirely satisfactory, and the committee makes no recommendation for change. However, in view of their recommendation for the adoption of the reinforced flange design, they recommend that the old gauge for mounting standard flange cast iron wheels be eliminated from the standards. As explained in last year's report, the new design gauge can also be used on the old style flange wheels, as the check gauge distance, that is, the distance from back to throat, is the same."

Maximum and Minimum Flange Gauges

The report called attention to the fact that last year the Association adopted the maximum flange gauge shown in Fig. 1 for use on new reinforced flange cast iron wheels, and pointed out that if the Association adopts the new flange as standard, as the committee recommended, it will be necessary to adopt a minimum flange gauge. It added: "With the old flange, an allowance of 1/16 in. over and 1/16 in. under normal was permissible. The committee felt that these limits were too wide, and the manufacturers have agreed that they can work to closer tolerances. Therefore, it is proposed with the new type of reinforced flange wheel to limit flange thickness tolerance to 3/32 in. The old type of maximum flange gauge shown in Fig. 2 for use on standard flange wheels is within 1/164 in. of the proposed minimum for reinforced flange wheels and to avoid the necessity of the railways purchasing new gauges, it is recommended that the old maximum flange gauge be adopted as a minimum flange gauge for the new reinforced flange wheels, and the old minimum flange gauge shown in Fig. 3 be retained for use on steel wheels only." These gauges are shown in the accompanying illustrations.

Gauging Journal Length

The report called attention to the method shown in the 1926 report for measuring length of journals on axles, and stated that numerous gauges have been submitted to the committee, some of which were patented and some not. The committee did not feel that any of the unpatented gauges presented were suitable, and reported that it is still of opinion that the method of measurement recommended in its 1926 report is the best. The report said: "It is believed that many axles are being improperly condemned, because of the use of a wrong type of gauge, and the committee again wishes to call the Association's attention to the standard method which has been established. In general, it appears that inspectors are often over-technical in condemning axles for over-length journal. There is no factor of danger involved in this defect, and condemnation, for over-length of 1/32 in., for example, is not good practice. We may also call attention to the practice followed in some cases of turning down the dust guard seat in an effort to shorten the length of the journal. This is a poor practice, as metal is taken off at the vital part of the axle, and the fit in the dust guard is spoiled."

Other matters dealt with in the report included worn through chill defect; wheel defect gauge; measurement of tread worn hollow in locomotive tires; defects in wrought steel wheels; engine truck wheels; relations with manufacturers. In regard to the latter, the committee reported close co-operation with the Association of Manufacturers of Chilled Tread Wheels, and the wrought steel wheel manufacturers' technical committee.

Power Brake Investigation Report

H. A. Johnson, director in charge of the power brake investigation which is being carried on on the Association's test rack at Purdue University, presented a report for the committee on safety appliances, on the progress of the brake tests, it being supplementary to the reports on the same subject presented at the 1925, 1926 and 1927 meetings. Rack tests for the standard Westinghouse type K brake, the Automatic Straight Air Brake Co. brake, the Westinghouse type F. C-5 brake, and the Westinghouse type FC-3 brake were arranged for at the start of the investigation. Up to the time of reporting for this year's meeting, the rack tests on the first two had been completed, and it was expected that the rack tests of the FC-5 brake would be completed by July 1, 1928. At the time of reporting, 621 rack tests had been made with 100 type K triple valves, 602 tests with 100 Automatic Straight Air Brake Co. brakes, 188 tests with mixed equipments of 50 type K and 50 A. S. A. brakes, 611 tests with 100 Westinghouse type FC-5 brakes, and 168 tests with mixed equipments of 50 type K and 50 type FC-5 brakes.

Some of the features claimed for the FC-5 brake are as follows:—1. Elimination of undesired quick action. 2. Emergency quick action available at any time with high emergency brake cylinder pressure. 3. Graduated release. 4. Maintenance of brake cylinder pressures against leakage within certain limits of time pressure. 5. Compensation for variations in piston travel. 6. Detection of excessive brake cylinder leakage in direct release operation.

Of the four equipments being tested, the Westinghouse FC-5 equipment and the Automatic Straight Air Brake Co.'s brake were designed to meet all of the Interstate Commerce Commission tentative specifications and requirements. The Westinghouse FC-3 equipment, which embodies the Westinghouse Co.'s ideas as to the desirable functions of air brake equipment for long trains, and which is submitted to the American Railway Association to further its investigation to determine what improved appliances or devices are available, and what improvements, if any, in power brakes and appliances may or should be made to increase safety, does not provide for the maintenance of brake cylinder pressure against leakage, nor for the graduated release of brake cylinder pressure, which are two of the I. C. C. tentative requirements. Upon completion of the rack tests, such equipments as have shown sufficient merit will be subjected to road tests. A tentative schedule of road tests is being drafted, and upon completion will be submitted to all interested parties. The testing laboratory was visited by large numbers of railway men and others during the year.

Couplers and Draft Gears Committee's Report

The couplers and draft gears committee referred to the description given in the 1927 report of the A. R. A. draft gear testing laboratory, and of the organization for conducting the tests, and added: The draft gears being tested are what may be termed the standard freight gear of the manufacturer. In each case the manufacturer was requested to submit full information covering all draft gears intended for use in the standard 24⅝ in. pocket, together with his recommendations as to which type of gear should be tested, and these recommendations were carefully considered when deciding upon the design or type of gear. Draft gears from the following manufacturers are included in the tests now arranged for: National Malleable and Steel Castings Co., Bradford Corporation, Westinghouse Draft Gear Co., Waugh Equipment Co., Hall Draft Gear Corp., Standard Coupler Co., W. H. Miner, Inc., Keyoke Railway Equipment Co., Edgewater Steel Co., and Union Draft Gear Co. Ten draft gears of each design are subjected to test, the capacity and characteristics of 8 being obtained under the 27,000-lb. tup, and of 2 under the 9,000-lb. tup. Five of the 10 gears are then subjected to the endurance or wearing-out test and 5 to the sturdiness test, the latter being to show the ability of the gear to withstand over-solid blows. The 27,000-lb. tup is used in these two tests. The interest taken in the A. R. A. research work being carried on at Purdue University is indicated by the large number of visitors on Nov. 11, 1927, when public demonstration tests were run at the draft gear testing laboratory, 282 visitors representing 64 railways and 53 manufacturing companies having registered. The draft gear tests are progressing satisfactorily, and it is anticipated, unless some gears develop unexpected endurance, that the actual testing should be completed by the end of this year, which is somewhat earlier than was originally expected.

Pivot Pin Hole in D Coupler

The report stated that the manual does not show the dimensions of the pivot pin hole in the coupler body, and the fact that this hole is elongated and not round has resulted in some misunderstandings and controversy with the coupler manufacturers. Accompanying the report was a detail drawing of the knuckle pivot pin hole, showing that the hole is 1¾ x 1 11/16 in., the larger dimensions being parallel with the coupler shank. The secretary has been requested to insert this drawing in the Manual.

Origin of Engine Whistle

How many people have ever thought of the origin of the locomotive whistle or who invented it? It was brought into use through an accident on an English railroad 100 years ago, according to the Claim Agents' Bulletin. When the Stockton and Darlington railway was opened for traffic there a man on horseback preceded the Samson, one of Stephenson's early locomotives, to warn people of its approach. But Stephenson's engine attained the hitherto unheard-of speed of fifteen miles an hour and ordered the horseman off the track.

The first serious crossing accident on the road followed on September 15, 1830, when the Hon. William Huskisson, a cabinet minister, was killed. Incidentally he was the first man killed by a locomotive. Another accident occurred on May 4, 1833, when a train collided with a farmer's wagon containing 50 pounds of butter and 80 dozen eggs on a crossing between Thornton and Bagsworth, England. After this a meeting of the directors was called to consider what steps could be taken to obviate a repetition of such accidents.

Stephenson made the suggestion of the steam whistle which was welcomed and accepted by the directors and a musical instrument maker in the town of Leicester was engaged to make it. The trumpet or horn, as it was called, was about eighteen inches long and six inches across the bell.

Railway and Locomotive Engineering

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New Austrian Locomotive Designed to Avoid Electrification

Less than three decades ago there was slight difference in the performance of locomotives in Europe and those in the United States; while today, America has not only far outgrown European achievements in size and power but is leading in the adoption of new wheel arrangements and auxiliary apparatus such as boosters, stokers, etc.

Those who saw the Baltimore and Ohio exhibition last year were impressed by the dainty appearance the locomotive King George V, the most powerful passenger locomotive of England, made between the American giants.

On the other hand, American engineers have always appreciated the fine workmanship of European locomotives, and it is through close study and critical comparison of European and American practice, that greatest benefit can be derived for the profession as a whole.

Unlike in England, where great density of traffic with light trains is a characteristic feature, continental railroads struggle with increasing train weights, and a strong demand for higher speed makes for difficult problems to be solved, specially as the maximum axle load on most railroads there lie between 35,000 and 40,000 pounds. Therefore, the eight-coupled locomotive is gaining ground in through passenger service even on easier grades. It is of interest to note that the Austrian Federal Railways have ordered the heaviest and most powerful high-speed locomotive in Europe for service between Vienna and Salzburg, where the maximum grade is 1.1 per cent. The engine is briefly described elsewhere in this issue.

This engine, which is expected to develop 3,000 horsepower at 75 miles per hour, is of the 2-8-4 type, a wheel arrangement introduced by the Lima Locomotive Works for freight service in 1925. The new engine of the Austrian Federal Railway represents the first of this wheel arrangement designed for the high speeds indicated in the description of the locomotive previously referred to.

The engine will undergo thorough tests shortly after its delivery in October. It was especially designed to prove that the proposed electrification of the road will be unnecessary with the much less costly purchase of up-to-date steam power. Sharp guarantees had to be given by the designers and builders and its performance record will prove highly interesting.

The new Series 214 locomotive of the Austrian Federal Railways is a representative example of the progressive tendencies of the railways of that country in the face of adverse conditions and the destructive effect of the world war.

Transportation in the United States

Elsewhere in this issue will be found an article on the Effect of Motor Trucks, Busses and Aerial Transportation on Railways, in which it is sought to show that our railways have no cause for alarm in other competitive forms of transportation.

We are a nation of travellers and shippers, and it is fair to assume that our requirements in these matters will increase in obedience to our scale or manner of living, rather than on a population basis as the following tabulation indicates:

Year	Miles of Railway	Population	Total Railway Revenues	Average Per Capita	Per Cent Increase
1890	156,404	62,947,714	$1,051,877,000	$16.71	Zero
1900	192,556	75,994,575	1,487,044,000	19.56	
1910	240,831	91,972,226	2,750,667,000	29.90	
1920	250,834	105,710,620	6,300,000,000	59.60	
1927	250,000	118,000,000	6,400,000,000	54.23	224%
*1940	252,000	143,000,000	10,000,000,000	69.91	318%

*Items estimated.

Each year brings new developments in the multiplicity of our activities, political, financial, industrial, civic and religious, all of which either directly or indirectly affect transportation of various kinds, but almost invariably with an increased demand.

People are no longer content to either remain at home or consume only home products. On the tables in New England homes we find fruits and vegetables grown in Florida and California, while meat of the reindeer from Alaska is being served in homes 2,000 to 4,000 miles away, and in a country unexcelled for choice meats and sea foods of all kinds.

The same is true of most all necessary commodities of life and particularly the luxuries, and as for travel, the rich have always travelled at will, and now it is only the extremely poor that stay at home.

Our ultra modern luxurious railway trains no longer satisfy all those who travel either on business or pleasure. Therefore, many already have and others will take to the skies, thus increasing the demand for passenger transportation in the air. In addition to these, some of the lighter and more valuable shipments now made by express and parcel post will be so handled.

The volume or bulk of business that can stand the necessary tariff rates by air, however, is so relatively small that when compared to the total at present, and future prospective volume, there isn't any probability of either the aerial or motor trucks and busses doing the railways any serious damage.

As brought out in the article, the shrinkage in passenger revenue has been accompanied by an increase in freight business of about 14 to 1, and if there is anyone in any business who is not willing to trade a loss of $1.00 on an item, for a gain of $14.00 on another, then they deserve to fail.

It must be borne in mind that the loss in passenger revenue is most all from coach passengers, who as a rule only travel a short distance. This is easily understood when we recall that commencing with 1911 when there were only 619,500 passenger automobiles, that we now have 20,230,429 passenger autos and their owners are using them, to which the reduction in short haul coach passenger business most abundantly testifies.

At the present time about 75,000 travellers on our railways go to bed each night in Pullman sleepers. A few years ago the number ranged from 40,000 to 50,000. The number will probably increase to 85,000 or 90,000 by 1940, and while motor bus and transport concerns will also develop their facilities, it will in all probability be many years before they attract as many as 10,000 sleeping car passengers per night.

Don't sell railroad securities through fear that the airplane or motor bus and trucks will put the railways out of business.

Training and Education of the Apprentice

It has been stated that during the past fifty years the civilized world has made greater progress and accummulated more wealth than it did during all the centuries from the birth of Christ to that time. Our progress has been likened to the movement of a falling body, that increases in speed; constantly adding to that which it previously possessed until it reaches a velocity so great that gravity can no longer keep pace with it, when it continues to move at a uniform rate. We are still in the condition of constant and uniform acceleration. What our rate of improvement will be when our pace is no longer accelerated, it would be hazardous and futile to predict.

But the impetus given us by the events of the past decade will not be lost. And one of the things that calls for a solution is that of the preparation of the workers. It is a matter that is being given most serious consideration by all who have to do with industrial matters on a large scale. Corporation schools are coming into existence on every hand. Men are being trained as never before for specific duties. The old time training of the apprentice, wherein he was taught the rules of his trade and the skillful manipulation of his tools, has taken on an added significance by including, as quite as important as the manual training, the development of the mind and the inculcation of the rational of what he does. He is being taught not only the *hows* but the *whys* of his work. There are corporation schools whose sole purpose is to take the young man and train him not only to do the immediate work in hand, but to fit him to occupy the official positions of executive control that the companies have to offer.

As it was said of the Napoleonic armies that every soldier of France carried a marshall's baton in his knapsack. So now we may say that, where these corporation schools exist every apprentice boy carries the president's gavel in his shop kit.

Railroad Consolidations and Motive Power

The first efforts in the direction of railroad consolidation were not conspicuously successful, albeit they provided ample food for reflection. As might have been expected, the objections of minority stockholders and the fears—real or pretended!—of politicians have, for the present, deferred constructive action.

Without going into specific cases or some of the proposed consolidations, it would seem that roads which have worked in close association for many years and having common interests should be permitted to consolidate. Such roads have a right to expect that their harmonious relations will not be disturbed at the behest of uninformed or mischievous persons, and that their arrangements for serving the public in the most economical and efficient manner will not be overthrown without due and proper inquiry.

This matter is exceedingly important as upon it hinges the solution of many problems, including the question of abandoned trackage and the extent to which the standardization of motive power and rolling stock can be carried.

Thinkers who have given any time to the subject realize that railroads are essential to society as at present constituted and as we are likely to know it for many years to come. The only question, then, is whether the railroads are to be first-class in every respect or only "so-so."

If they are to be first-class—and most people agree that they should be—would it not be a good plan to consider the views of practical railroad men and financial experts? They, certainly know quite as much about the subject as the gentlemen who spill a vast deal of oratory upon a puzzled populace and rant about "watered stock" and official corruption.

Men who have studied the steam locomotive for upwards of forty years are learning new things every day. How, then, can men who do not know a crank-pin from a cross-head claim to understand the entire railroad business and dismiss, as trivial, the opinions of those who have sweated to gain their information?

Allow me to remind the critics of the railroads that many of the officers "began at the bottom" and learned the business by taking a succession of "hard knocks." Handling a "scoop" or knocking ice off brake-rigging could not be classified as parlor pastimes, but they taught many a boy his early lessons in the art of railroading. He does not whine about it today, but he does think that he is at least as capable a judge of what is right and proper in the railroad business.

Many people believe that standardization, following as the result of consolidation, will introduce economies into the motive power departments of railways. No doubt, many benefits will ensue from the elimination of obsolete equipment. It is well to keep in mind, however, the fact that improvements are being made in the design and construction of locomotives, and that a rigid policy of standardization would be premature just now.

A study of the through passenger business on certain railroads will show that conditions vary considerably, and that reasonable latitude must be given to motive power officers in order to obtain the best results.

For example, a prominent trunk line desires to reduce expenses by running two sections of a famous limited as one train. In accordance with this plan, a new class of engines has been designed, incorporating a number of special features.

Another road, famous for its fast services, is content with a class of engines of less elaborate design. The reason is that frequency of service is the main requirement; and this operates to keep the weight of trains within certain definite limits. Nothing would be gained by the use of more powerful engines. As a matter of fact, their use might prove to be a distinct disadvantage.

Here we see the fallacy of attempting to prescribe a standard for passenger engines even when both roads are low-grade lines. Moreover, my friends in the supply trade frankly tell men that they do not recommend their devices in all cases, but only where the best results are reasonably certain of attainment.

It is undoubtedly true that a certain group of roads in the West could save money by uniting their motive power departments under one head and adopting a set of standards for all of the lines. These roads have been on friendly terms for years, and should be able to work out the details amicably and without any sacrifice of efficiency. The chief motive power officer of one of these roads has done some tremendously brilliant work in his own bailiwick, and could effect some wonderful results for the entire group. The scheme would not work any hardships to anyone, but would simplify maintenance and dispose the united resources in such a way as to make them most effective. Consolidation would hasten the happy day!

Industrial Safety

During the year ended June 30, 1927, more than 95,000 human beings lost their lives in accidents occurring in the factories, and on the streets and highways of this country. In New York State factories alone almost 99,000 people were injured so severely that they received money compensation—1,042 of those 99,000 died as a result of their injuries. These accidents, most of which preventable, cost New York State in excess of $100,000,000. Charging deaths and permanent disabilities with a loss of 1,000 weeks each, injured employes were absent from work a total of more than 2,000,000 weeks.

Here is a condition, the relief of which demands the interest and effort of every human being, whether he sits in the president's office or works at a bench.

Here is a situation in which there can be no major controversy. The conservation of life and limb is of prime importance to both employer and employe, for death and disability cause loss to them both.

The solution can be found only in their combined effort; for divided they can accomplish but little.

Industrial Safety is not a new subject. It is recorded that some thought was given to it in 1867. The problem of employes relationships as a whole was considered as early as 1,800 when Robert Owen, Scotch mill operator, set up a paternalistic personnel program among his workers.

Robert Owen's effort was but the sowing of a seed. The harvest is contained in an ultimate civilization, the character of which we cannot conceive, but the fabric of which is being inevitably woven from the warp and woof of individual human thought and accomplishment.

Electrification on the Pennsylvania Railroad

The Board of Directors of the Pennsylvania Railroad Company has authorized the electrification of the entire road train service, freight and passenger, between New York and Wilmington, Delaware.

This authority covers part of a plan which includes also electrification of the grades between the Susquehanna, Schuylkill and Delaware River valleys and our eastern terminals.

The project as now announced covers the passenger and freight service on 325 miles of line and 1,300 miles of track, beginning at Hell Gate Bridge, New York, where connection is made with New England, and extending west and south to Wilmington, west from Philadelphia on the Main Line in the direction of Harrisburg as far as Atglen, Pa., and the low grade freight lines which join at Columbia, Pa., and connect the cities of New York, Philadelphia and Wilmington with the West.

This electrification will far exceed in magnitude and in importance that of any other railroad in the world, in miles of track to be electrified, in volume and density of passenger and freight business handled, in size and amount of equipment required, in the number of trains affected, and in terminal operations involved. The project will be undertaken progressively in sections and extend over a period of years.

It is estimated that the cost of this electrification will be approximately $100,000,000, to be spent, however, during the next seven or eight years at the rate of about $15,000,000 per year; sixty per cent of the total being for catenary, transmission line and sub-station construction, and forty per cent for rolling stock.

Economic Situation in the Railway Industry

A Review of the Year of 1928 As of October First

A summary of transportation conditions and performance of the class 1 railways for the period January 1 to October 1, 1928 has been issued by the Bureau of Railway Economics and gives, as far as figures are available, an analysis of traffic, revenues and expenses, capital expenditures, purchases of materials and supplies, and the principal factors in operating efficiency, and of which the following is an extract.

Revenue freight loadings aggregated 42,917,925 cars during the first 43 weeks of 1928. Until the first week of September with only five exceptions, the weekly loadings for 1928 ran consistently behind those for 1927. Since that time they have run consistently ahead of 1927.

Net ton-miles show a similar trend. To the end of June they were less month by month than in the same periods of 1927, but the percentage of decrease under the preceding year tended to grow smaller, and in July it turned upward. The aggregate for the nine months is 2.3 per cent below that for the first nine months of 1927, and about the same percentage below the corresponding period of 1926. The following table compares by months the freight traffic of 1928 with that of 1927 and 1926:

NET TON-MILES
(RAILWAYS OF CLASS 1)

	1928 (*millions*)	*Per cent increase or decrease compared with* 1927 (*millions*)	1926 (*millions*)
January	36,269	dec. 7.6	dec. 3.7
February	35,701	dec. 4.2	inc. 0.8
March	39,467	dec. 5.6	inc. 2.1
April	35,866	dec. 3.4	dec. 1.2
May	39,250	dec. 2.2	dec. 1.5
June	37,304	dec. 3.0	dec. 5.0
July	39,196	inc. 2.2	dec. 6.0
August	42,406	inc. 1.0	dec. 3.0
September	43,778	inc. 1.9	dec. 1.3
Nine months ..	349,164	dec. 2.3	dec. 2.2

Estimating the probable results of the later months of the year, it would seem that the aggregate net ton-miles for 1928 will approximate a toal of 470 billions,—a decrease of about one per cent under 1927 and three per cent under 1926.

Revenue passenger-miles for the first nine months of 1928 declined 6.6 per cent under 1927. With the exception of 1923, every year since 1920 has shown a decrease under the next preceding year.. If the loss already sustained in the passenger traffic of 1928 continues to the end of the year, passenger-miles will be 33 per cent under the record year 1920 and the lowest of any year since 1909.

Revenues and Expenses

Total operating revenues for the first nine months of 1928 were 4,534 millions of dollars, a decrease of 124 millions, or 2.7 per cent, under the corresponding period of 1927. This decrease in revenue reflects the reductions of more than two per cent in freight traffic and more than six per cent in passenger traffic.

Total operating expenses were 3,341 million dollars in the same nine months, a reduction of 134 millions under the corresponding period of 1927, or 3.9 per cent. Transportation expenses were reduced $65,000,000, or 4 per cent. Maintenance of equipment expenses were reduced $48,000,000 or 5 per cent, and maintenance of way expenses $25,000,000, or 4 per cent, a total reduction of $73,000,000 or 4.6 per cent in maintenance expenses as a whole. That the reduction in maintenance of equipment expenses resulted from greater operating efficiency is indicated by the fact that the proportions of locomotives and of cars in serviceable condition have been virtually stationary. These various reductions in operating expenses during the first nine months of 1928 mark the extent to which the railways have kept their expenses in hand during the current year. Only the application of the most rigid economy has saved railway net income from showing a large decline.

Net operating income was 820 million dollars, an increase of ten million over the same nine months of 1927. The rate of return on investment, however, slightly declined.

Railway investment shows a continued increase, year by year. During recent years the net operating income has not kept pace with the increase in investment, leading inevitably to a marked decrease in rate of return since 1926.

The net operating income of that year—the entire year 1926—was the largest in railway history, resulting in part from the greatest freight service ever rendered to the American people. Between 1926 and 1927 property investment increased, while net operating income declined. The rate of return on investment of course fell. From 1927 to 1928 the investment has again increased, while net operating income showed only a slight rise. The increase in net income was relatively smaller than the increase in investment, and the rate of return therefore declined. That rate of return was 4.55 per cent during the first nine months of 1928, contrasted with 4.60 per cent during the corresponding period of 1927. These rates for nine-month periods have been placed on an annual basis of comparison.

Wages and Taxes

Wage levels continue to rise. Average earnings per hour for all classes of employees in the first eight months of 1928 were 67.8 cents per hour, an increase over the same period in 1927 of 1.3 cents. Applied to the total hours of service of a typical year, this amounts to an annual payroll increase of approximately $60,000,000 from increase in wage rates. Adjustments of wage rates of several classes of railway employees during the past two or three years are reflected in the continued increase in average hourly earnings.

Taxes show a slight reduction so far this year, but a reduction relatively smaller than the decrease in revenues. The ratio of taxes to operating revenues has therefore increased, standing now at the highest point ever known. In the first nine months of 1928, 6.30 cents out of every dollar of revenue was absorbed by taxes, contrasting with 6.17 cents in the same period of 1927. The ratio of taxes to revenue during the ten-year period from 1917 to 1927 ranged between a minimum of 4.4 cents per dollar and a maximum of 6.1 cents per dollar, the trend being almost constantly upward.

Railway Capital Expenditures

The railways this year, as in every preceding year, have been expending new capital on plant improvements, new equipment, and other facilities. The capital so invested in railway additions and betterments during the first nine months of 1928 aggregated $500,000,000.

Summary figures for 1928 and 1927 follow, while the details appear in Table I of the Appendix.

Item	*Capital Expenditures, nine months ended September 30* 1928	1927
Equipment:		
Locomotives	$ 37,121,000	$ 53,721,000
Freight-train cars	89,920,000	104,565,000
Passenger-train cars	27,187,000	31,383,000
Other Equipment	11,739,000	15,323,000
Total equipment	$165,967,000	$204,992,000
Roadway and Structures:		
Additional track	$ 91,241,000	$108,002,000
Heavier rail	34,891,000	35,199,000
Additional ballast	12,621,000	10,669,000
Shops and engine houses	22,375,000	28,102,000
All other improvements	173,072,000	183,251,000
Total Rdwy. and Struct.	$334,200,000	$365,223,000
Grand Total	$500,167,000	$570,215,000

It will be seen that gross capital expenditures for all purposes are $70,000,000 less than in 1927, or about 12 per cent. Capital expenditures for roadway and structures declined $31,000,000 or 8.5 per cent, while capital expenditures for new equipment were less by $39,000,000, or 19 per cent.

Authorizations carried over, on October 1, 1928, amounted to $402,000,000. This was smaller by $25,000,000 than in 1927.

Railway capital expenditures for the year 1928 are estimated at approximately $650,000,000, an estimate which makes possible the compilation of the following statement, showing gross capital expenditures made since the close of Federal Control in 1920:

Railway Capital Expenditures

Class I Railways in the United States

Calendar year	*Amount*
1920	$653,267,000
1921	557,035,000
1922	429,273,000
1923	1,059,149,000
1924	874,743,000
1925	748,191,000
1926	885,086,000
1927	771,552,000
1928 (est'd)	650,000,000
Total—Nine years	$6,628,296,000

These expenditures for improved railway plant, aggregating more than six and a half billion dollars in nine years, comprise one significant contribution by the railway industry to commercial activity in the United States, as well as a vital contribution to operating efficiency within the industry itself.

Railway Purchases

Another significant contribution of the railways to commercial activity is measured by their purchases of fuel, materials, and supplies. Railway purchases in 1927 amounted to $1,395,928,000.

During the five years from 1923 to 1927, railways spent in direct purchases nearly seven and a half billions of dollars, or about a billion and a half per year. Table II in the Appendix summarizes the purchases made during that five-year period.

By "direct purchase" is meant items bought and paid for by the railways themselves. They also are indirect purchasers of many commodities that go into railway equipment, and into new construction contracted for under lump-sum agreements.

Railway Operating Efficiency

Large capital expenditures and close attention to efficiency have resulted in improved operating performance this year. Outstanding achievements are briefly indicated below, applying in each case to the first nine months of 1928, compared with the corresponding nine-month periods of the several years back in 1923, when the railway program for specific improvement in operating efficiency went into effect.

Car-miles per freight car-day show an almost continuous increase, from 27.6 miles in 1923 to 30.7 miles in 1928. In computing this average, account is taken of all freight cars in service, including cars in transit, cars in process of being loaded and unloaded, and cars undergoing or awaiting repairs, as well as cars on side-tracks for which no load is immediately available.

Net tons per freight train have increased from 718 tons in 1923 to 787 tons in 1928.

Freight train speed has risen consistently, from 10.8 miles per hour in 1923 to 12.9 miles in 1928.

The proportion of freight locomotives in serviceable condition has risen consistently each year, from 77.3 per cent in 1923 to 83.7 per cent in 1928.

Gross ton-miles per freight train-hour have increased continuously and markedly, from 16,607 in 1923 to 23,537 in 1928.

Fuel consumed per thousand gross ton-miles in freight service has shown progressive improvement, from 161 pounds in 1923 down to 126 pounds in 1928 for performing the same service.

Fuel consumption in the passenger service has also shown progressive improvement, from 18.2 pounds per passenger train car-mile in 1923 down to 14.9 pounds in 1928.

All these comparisons, as stated, are for nine-month periods in the respective years. Details underlying these comparisons, and other efficiency factors as well, will be found in Tables III and IV of the Appendix.

Another measure of operating efficiency is the combination of efficiency factors into an index, so that a convenient percentage basis of comparison may be used in connection with the average of some previous period. Using the five years 1920 to 1924 as a basic period, the average efficiency of the railways is taken as equivalent to 100.

Thirteen operating efficiency factors have been included in the "index," or composite average, namely:

1. Car-miles per car-day.
2. Ton-miles per car-day.
3. Gross tons per train.
4. Net tons per train.
5. Gross ton-miles per train-hour.
6. Net ton-miles per train-hour.
7. Locomotive-miles per locomotive-day (Freight).
8. Locomotive-miles per locomotive-day (Passenger).
9. Percentage serviceable locomotives (Freight).
10. Percentage serviceable locomotives (Passenger).
11. Percentage serviceable freight cars.
12. Fuel consumption per unit (Freight).
13. Fuel consumption per unit (Passenger).

These factors, combined and computed for the first nine months of 1928 and compared with the basic period, 1920-1924, give the following results:

	(*Average* 1920–4=100)
January, 1928	117.1
February	118.3
March	118.1
April	118.8
May	117.7
June	115.9
July	118.7
August	118.1
September	118.8

These index figures are the highest on record for each of the nine months of 1928 for which returns are available at present. Maintenance of the high level of operating efficiency is expected for the rest of 1928, so that the average for the year as a whole will be higher than for any preceding year. The corresponding averages for the entire years 1924 to 1927 are comparable with the first nine months of 1928 as follows, and show a definitely continuing progress:

	(*Average* 1920–4=100)
1924	104.8
1925	109.4
1926	113.5
1927	115.2
1928 (9 months)	117.8

The efficiency index figures here presented for the first nine months of 1928 mean that there was an improvement in railway operating efficiency in each of the individual months of from 15.9 to 18.8 per cent, compared with the basic period (1920 to 1924). When averaged over the nine months as a whole, the percentage of improvement was 17.8 per cent.

This efficiency index does not include the factor of tons per loaded freight car, for the reason that that factor is one for which responsibility is shared with the shippers. Improvement in this average was not shown in 1928, a fact that emphasizes the importance of sustaining every effort to increase the load in the car.

Net tons per loaded car (including less-car-load freight) during the first nine months of 1928 averaged 26.5 tons, the lowest in any corresponding period of the preceding five years. In 1927 it was 27.3 tons, and in 1923 stood as high as 28.1 tons.

The further significance of this point is apparent from a consideration of one of the thirteen efficiency factors that is included in the index, namely, net ton-miles per freight car-day, which is affected by the average load per car. This factor showed a slight reduction to 514 ton-miles during the first nine months of 1928, from 521 to 1927. This average for 1928 was higher than in 1923, 1924, and 1925.

In spite of the smaller load per car, the railways were able also to show a slight increase in net tons per train during the first nine months of 1928.

The most striking efficiency gain in 1928 was in gross ton-miles per train-hour, which was increased from 21,876 during the first nine months of 1927 to 23,537 in 1928. This was an increase of 7.6 per cent over 1927, and of 42 per cent over 1923.

The improvement in net tons per train was attained by the railways, in the face of a falling carload, through the greater use of facilities and improved motive power made available during the past five years by large capital expenditures. The large increase in gross ton-miles per freight train-hour reflects the greater train speed per hour, together with other factors.

Thus it appears that in the majority of factors for which railway managements were wholly responsible, the operating efficiency of the railways in 1928 has shown continuing improvement over the performance of the past five years. Their general efficiency during this period is marked not only by progress in many of the individual factors of performance, and by improvement in the general index of efficiency, but also by the economies which have enabled them to maintain their net income against declining traffic and revenues. How long this process can be continued is one of the important problems now confronting the railway industry, the shippers of the country, and the general public.

Further Developments in Oil Electric Motive Power on Canadian National Railways

High-Speed 2660-Hp. Oil Electric Locomotive Makes Initial Runs on Canadian National Railways

The Canadian National Railways have placed in operation the first unit of a 2660-hp. oil electric locomotive on their lines between Brockville and Belleville, Ontario. This locomotive, the largest and most powerful of its kind in the world, has made its appearance in just a little over three years after the appearance of the first oil electric rail car of 200 hp. rating on the lines of the same system.

High-Speed Oil Electric Locomotive of the Canadian National Railways

The locomotive, consisting of two units, weighs 650,000 pounds when fully equipped, of which 480,000 pounds is carried on the driving wheels. Each unit consists essentially of an oil engine generator set mounted on the locomotive frame, boiler equipment for steam heating of passenger coaches, four traction motors for propelling the locomotive, air brake and other auxiliary equipment.

The power developed by the oil engine is converted into electrical energy by the generator, transmitted to the traction motors geared to the driving axles, where it is utilized in developing tractive efforts and speed. With the present gear ratio which was laid out for high-speed passenger service, the locomotive will develop a tractive effort of 100,000 pounds during accelerating periods and 42,000 pounds continuously. The electrical system of transmission utilizes full engine horse power over a wide range of speed and tractive effort of the locomotive, without change of engine speed or shifting of gears. It also provides a quick and easy method for reversing the locomotive without stopping or reversing the oil engine.

The operation of the locomotive and the speed of the oil engine are controlled from either of two engineman's stations, which are located in separate compartments at the outer end of each unit. Means are provided for the control of both units jointly, or either unit independently of the other unit, from these stations. Gauges are mounted at each engineman's station for indicating the operation of each unit.

Each unit contains a Beardmore twelve cylinder oil engine of the solid injection type, 12 in. bore and 12 in. stroke. The nominal rating of the engine is 1330 hp. at 800 r.p.m. The engine is of the variable speed type, and may be run at any speed between idling speed at 300 r.p.m. and full speed at 800 r.p.m., the engine governor controlling the throttle to maintain the speed corresponding to the governor setting. A fractional horsepower electric motor, controlled from the engineman's station, is used for changing the speed setting of the governor. The engine develops its rated horse power at a fuel rate of 0.43 pounds per b.hp. hour. It will develop reduced power as may be required in locomotive service, with but a slight increase in the fuel rate per b.hp. hour. The engine is started from standstill by power taken from a storage battery on the locomotive, using the main generator to crank it over. The oil engines were designed and supplied by the William Beardmore Co. of Glasgow, Scotland.

The cooling of the oil engine is accomplished by circulating the engine jacket water through radiators of the honeycomb type mounted on the locomotive roof. The lubricating oil is circulated through tubular finned type radiators, which are also mounted on the locomotive roof. Both sets of radiators are force ventilated by motor driven blowers of the propeller type, although the natural ventilation resulting from the locomotive speed will be sufficient to cool the engine during cold weather, and will assist materially in cooling it at other times. The radiator blower motors are controlled by separate thermostats placed in the water and oil to maintain desirable operating temperatures for each. Means are provided for bypassing a part or all of the water radiators during initial warming up periods.

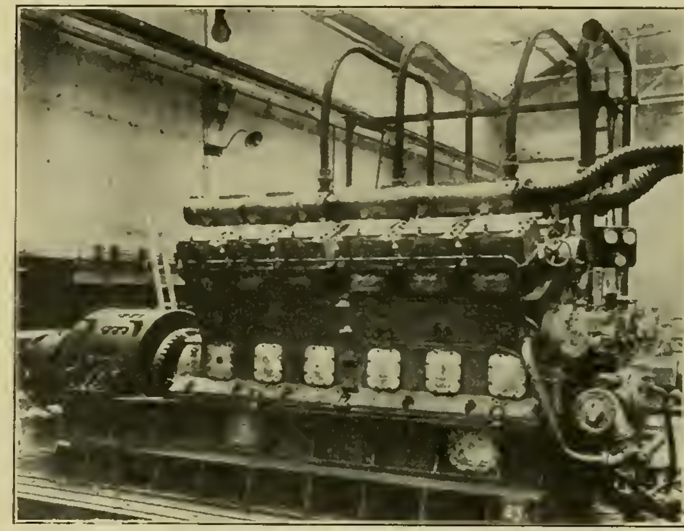
The exhaust gases of the oil engine are conducted to an economizing boiler located in the cab and finally discharged to the atmosphere at a reduced temperature. The economizing boiler also serves as an effective silencer in muffling the exhaust of the engine. The heat saving in the exhaust gas is sufficient to heat a passenger train of an average number of cars for outside temperatures as low as 12 degrees Fahrenheit below zero with the oil engines operating at average loads and for lower temperatures with the oil engines operating at full load. The heat saving effected by the economizing boiler results in a substantial increase in thermal efficiency of the locomotive.

An oil fired boiler has been installed in each unit which will operate in conjunction with the economizing boiler to supply steam for train heating during periods when the output of the latter does not meet the requirements. This boiler uses the same fuel oil as the engine and it has an evaporative capacity of 2,500 pounds of steam per hour to 100 pounds pressure. It is controlled automatically to maintain a constant pressure in the train heating system with the varying rates of evaporation of the economizing boiler. The automatic operation is accomplished by a pressure controller, which operates to increase the supply of fuel oil, atomizing air or steam, and combustion air, if the pressure falls below normal due to a reduced output from the economizer, corresponding with a reduced load on the oil engine, and conversely to reduce the supply of fuel oil, atomizing air or steam, and combustion air, when the pressure increases above normal due to an increased supply of steam from the economizer, corresponding with the increased load on the oil engine.

Automatic control of water injection pumps for both economizer and oil fired boiler, is provided to maintain the water at constant level in both boilers during periods when the demand for steam requires full output of the former and partial or full output of the latter. When the demand for steam is less than the capacity of the economizer, the oil fired boiler may be made inoperative and the output from the economize reduced by lowering its water level thereby reducing the evaporative rate. Under these conditions, the water level and consequently the evaporative rate of the economizer is controlled automatically by a pressure controller which operates to control the water injection pump. Under conditions where there is no demand for steam, the water level is reduced to zero and the economizer is operated dry as a silencer for the oil engine until such time as a demand for steam occurs, when water is injected into the economizer and it again functions as a boiler.

The economizer and boiler are of the thimble tube type, and were designed and furnished with the auxiliary steam control equipment by the Clarkson Steam Motors Co., Ltd., of London, England.

The electric generators, motors and auxiliary electrical equipment were designed for this particular service by the Westinghouse Electric & Manufacturing Company of East Pittsburgh, U. S. A. and were supplied by the Canadian Westinghouse Company of Hamilton, Ontario. The system of control provides for varying the speed of the oil engine, and generator voltage, and shunting the field of the series type traction motors for changing the speed of the locomotive. Torque governor control is used to insure continuous air supply and battery charging re-



Twelve Cylinder Beardmore Oil Engine of Canadian National Oil Electric Locomotive

gardless of oil engine speed and to automatically prevent overloading of the oil engine by regulating the main generator field current, maintaining a practically constant torque over the operating range of voltage and current. Remote control of generator and motor switches and of speed setting of the engine governor permits the multiple operation of the two units comprising the locomotive. Automatic reversal of radiator blowers occurs with reversal of the locomotive, to maintain the flow of the cooling air in such a direction that the blowers assist the natural flow of air due to the pressure developed by the direction of travel of the locomotive. Means are provided for stopping either or both oil engines from either engineman's station.

A motor-driven blower is installed in each cab to force ventilate the traction motors when conditions warrant in passenger service, and when in freight service.

The locomotive is equipped with Westinghouse type 14-E. L. air brake equipment, transfer valve, and brake valve pedestal. Each unit of the locomotive has a 75-foot motor driven air compressor which operates from the main generator during engine idling periods and from the auxiliary generator during power periods, thus insuring full speed under practically all operating conditions. Automatic means are provided to prevent application of power on reversal of locomotive with the driver brakes applied, to protect against sliding of wheels.

The foundation brake rigging, designed and supplied by the American Brake Company of St. Louis, represents the maximum in simplicity and flexibility for this type of chassis. Four driver brake cylinders are provided for each unit, two of which brake the two forward pair of drivers, while the other two brake the two rear pair of drivers. A fifth brake cylinder is provided for braking the four wheel engine truck. A hand brake is also provided for holding the locomotive when stopped, in case the air brake is inoperative.

A lead storage battery consisting of 56 cells of Exide M. V. A. 21, 340 ampere hour capacity, is carried on each unit. This battery is installed principally for engine starting but it also furnishes power for control, lights, and auxiliaries during part time. It is charged from the main generator during engine idling periods, and from the auxiliary generator during power periods.

The main frame of each unit consists of a Commonwealth casting having supports for the oil engine bedplate, boiler supporting casting, cab brackets, air duct, brake hangers and equalizer pins, cast integral with the side frame and crossties. The four-wheel and two-wheel truck frames are also of the Commonwealth type. The driver journals and two-wheel truck journals are waste packed, oil lubricated. The four-wheel truck journals are of the outside bearing type, floating bushing, grease lubricated. The equalization system consists of one point of support at the centre pin of the four wheel truck, and one point in the equalization system of each side, the drivers being side equalized with the two-wheel truck.

The mechanical design of the locomotive represents the result of the combined efforts of the Canadian National Railways, Canadian Locomotive Company, Baldwin Locomotive Works, Commonwealth Steel Company, and Westinghouse Electric & Manufacturing Company.

The cabs and running gear were built and assembled on the frame by the Canadian Locomotive Company and the locomotive was equipped by the same company under the supervision of the Canadian National Railways.

Each unit carries approximately 8000 pounds of fuel oil, 11,000 pounds of boiler water, 3,000 pounds of engine jacket cooling water, 3,000 pounds of sand, and 1,000 pounds of engine lubricating oil.

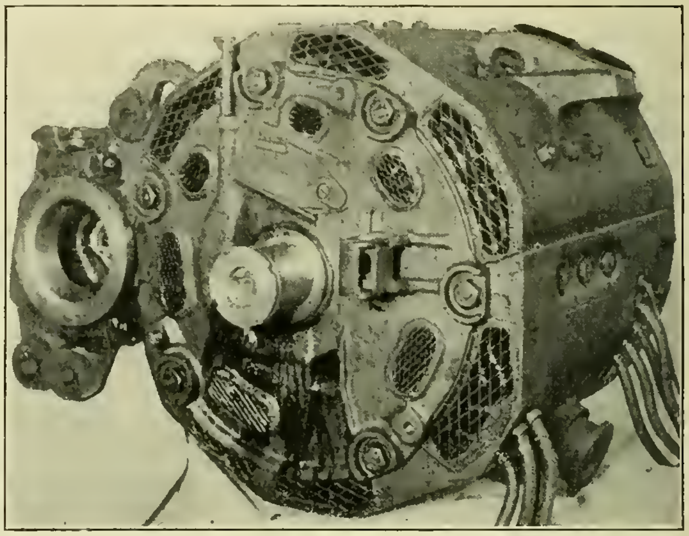
The supply of fuel oil will be sufficient for operation of oil engine and oil fired boiler, operating under average conditions, for twelve hours. A motor driven pump is mounted on each unit for filling fuel oil tanks. An oil filling pipe is installed on the locomotive for filling either unit from a tank car at the end of the locomotive.

The supply of boiler water will be sufficient for heating a train of average length for periods of from six to twelve hours, depending upon outside temperatures.

The traction motors are geared for passenger service and will develop 100,000 lb. tractive effort with this gear ratio during accelerating periods. The locomotive will handle the heaviest passenger trains at a high schedule speed. With the present gear ratio in freight service, the tonnage which can be handled will depend upon the ruling grade and is limited by the heating of the electrical equipment.

Assuming a ruling grade of 0.4 per cent, it will handle trains of 2800 tons made up of 45-ton cars, under average weather conditions, at a speed of approximately 19 m.p.h. on this grade, with a balancing speed of approximately 40 m.p.h. on level truck.

Assuming a freight gear ratio of 18:73, the locomotive will be capable of developing a maximum tractive effort of 130,000 lb. during accelerating periods with momentary tractive efforts limited by adhesion. It will handle a trailing load of 3700 tons, made up of 45-ton cars, under average weather conditions, on a ruling grade of 0.4 per cent at approximately 15 m.p.h. and it will have a balancing speed of approximately 35 m.p.h. on level track.



Four Westinghouse Motors Per Cab in the Canadian National Railways Oil Electric Locomotive

The oil engines of both units are arranged for the future application of a super charger, one of which has been built and tested on both engines. The super charger will be installed on one of the units for service tests in operation on the Railways lines.

Condition of Motive Power

Locomotives in need of repair on the Class I railroads of this country on November 1 totaled 8,177, or 13.9 per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was a decrease of 429 locomotives compared with the number in need of repair on October 15, at which time there were 8,606, or 14.6 per cent.

Locomotives in need of classified repairs on November 1 totaled 4,414, or 7.5 per cent, a decrease of 234 compared with October 15, while 3,763, or 6.4 per cent, were in need of running repairs, a decrease of 195 compared with October 15.

Class I railroads on November 1 had 4,958 serviceable locomotives in storage compared with 5,098 on October 15.

Railroad Finance

By Col. B. L. Bugg, President Atlanta, Birmingham & Coast R.R.

Before discussing railway finance, I think we should consider the corporation, that is, corporate entity and existence. There is perhaps a widely held opinion that the corporation method of doing business is of comparatively recent origin. Archaeologists tell us this method was known and in use in the time of the Babylonian Empire. It was a favorite form of business organization in conducting commerce in the time of the ancient Romans. I think the failure to appreciate the real meaning of a corporation has been the cause of much misunderstanding between the railroads and employees and between the railroads and the general public. A corporation was defined more than one hundred years ago by Chief Justice Marshall of the United States Supreme Court, as "an articifical being, invisible, intangible and existing only in contemplation of the law," which is what the lawyers call a legal fiction. More than 160 years since, Sir William Blackstone defined a corporation as "an artificial person created for preserving in perpetual succession certain rights which being conferred on natural persons only would fail in the process of time," which is the lawyers' way of saying the rights of natural persons die with them, while a corporation is, for all practical purposes, perpetual.

It is this thought of separate entity that I want to get into our minds today. No one ever becomes a part of a corporation. It is utterly impossible. In the time of slavery three persons could jointly own a slave, but the slave had a personality apart from the ownership, and so it is with a corporation. It is not like a partnership. A person can not become a part of corporation entity. We must bear in mind that the ownership of a corporation does not carry with it any personal responsibility, except as provided for in the law. If a corporation is owned by rich men, it does not follow that it is a rich corporation.

In the financial set up of a corporation the funds are divided into two classes. Those that are owned and those that are borrowed. The only funds that a corporation owns are those that are secured by the sale of stock or from revenues from its operations.

The stock is usually divided into two classes, common and preferred. The stock, while usually of a par value of $100.00, may be of any different denominations, $50.00, or $1.00, or may be of no par value. Most of the railroad stocks have a part value of $100.00, exceptions being the Pennsylvania, Lehigh Valley, Reading, Lackawanna and Union Pacific preferred, these stocks have a par value of $50.00. It is becoming more popular for corporations in general to issue stock of no par value. The par value is a misnomer and is misleading. The stock is only a certificate of the interest ownership in the business. If a corporation were incorporated for $25,000, and you held $5,000 of the stock, you would be a one-fifth owner of the corporation. The holders of the common stock are recognized as the owners of the corporation, and they are responsible for the conduct of the business and for carrying it on.

Preferred stock is usually issued in $100.00 denominations. A local corporation, the Georgia Power Company, has issued a preferred stock of no par value, and the dividends promised are stated as so many dollars per share. The market value is created by the demand.

In the reorganization of the A., B. & A., and in setting up the financial structure of the A., B. & C., the common stock was issued of no par value. The preferred stock, which went to the bondholders in settlement of their claims against the property, was issued at a par value of $100.00. When a corporation is organizing, it is usually started out by an issue of common stock. Stock is issued for some of the money, and some of the money is borrowed. It was considered sound finance formerly to issue 75% in stock and borrow 25%, or three-quarters owned capital and one-quarter borrowed. The pendulum has now swung the other way. In many corporations the stock issue represents 25% and bonds 75% of the capitalization. Mr. Woodlock, of the Interstate Commerce Commission, has recently called attention to the topheaviness of some of the railroad financial structures.

It must be borne in mind that, owing to the failure to show satisfactory returns over a period of years, the railroads have found it impossible to sell their stock advantageously, and have gone the limit in the issue of bonds. Since the present laws were passed, allowing them a reasonable return and showing that the railroads were to be dealt with fairly, there has been a disposition on the part of the successful roads to issue stock intead of bonds. Unprosperous roads can not make any headway in the issuance of stock to secure more funds.

Bonds are issued for borrowed money. They are simply certificates of indebtedness to the lenders of money just as a note you give at the bank when you borrow money. A bond is an evidence of debt, which is secured by a mortgage on the property, just as you borrow money on your home, and the holder of the mortgage may or may not issue bonds against the mortgage. There are several varieties of bonds. There is the first mortgage gold bond, which means that the money is secured by a first mortgage on the property and that it is payable in gold. There is the collateral trust bond which is usually issued on the security of stocks of bonds of subsidiary companies and owned by a parent company. They are deposited with a trustee and bonds issued against them. It is rather an interesting side light on finance that it is much easier for a parent company to secure funds on security of bonds or stock issues of subsidiary companies by putting them up as collateral, than to offer them as direct obligations.

Then, there is the debenture bond, which is only an acknowledgment of debt, and is not protected by mortgage of specific property, and in the case of insolvency of the company, the holder becomes a general creditor of the company. It is used more in England than in this country.

There is another issue known as the income bond, which came into existence about fifty years ago and was invented for the purpose of decreasing funded debt. The income bond is of little more value than the preferred stock, and has no claim against property, except for income as earned.

There is another bond very popular for financing railroad equipment known as the equipment trust. The railroad puts up in cash a percentage, usually about 25%, of the cost of the equipment to be purchased, and the banker creates an equipment trust, and bonds are issued for three-fourths of the value, and payable one-fifteenth each year. They are considered very desirable securities, and command better prices than general mortgage bonds.

During the A., B. & A. receivership, we found ourselves with our equipment in very bad condition, and without funds to rehabilitate it. There were already liens on the equipment under the existing mortgages. We had to get the trustees to temporarily release the liens against it, and permit the Receiver to issue equipment notes in sufficient amounts to put it in good repair. While the notes were running the cars earned funds sufficient to retire the obligations. Some of our friends likened it to lifting one's self by the bootstraps.

I now come to that other question as to how a railroad operates. The principal receipts are from freight and passengers, and they come in to the Treasury of the Company through the remittances or deposits in designated banks by agents and conductors. Under the modern methods of accounting agreed to by the principal roads, we also receive remittances for interline freights and tickets about the 25th of each month for the preceding month. Another item is bills collectable against other railroads, individual firms and corporations for rents, and for various services performed. These are the sources of money that come into the hands of the treasurer. Then he has to pay it out. First and most important is the pay roll; you are all perhaps more or less familiar with this feature of railroad finance. Then, there are the accounts for material and supplies, which are run through the books currently each month and classified in the expenses. Vouchers are made and checks drawn in favor of the parties to whom the accounts are payable. If a road has a sufficient working fund, these checks or vouchers are sent out currently. Whenever its funds are limited and it has heavy obligations to meet, as the payment of interest or taxes, etc., the favorite indoor sport of a railroad treasurer is to hold back the vouchers for material and supplies, and the poor material and supplies man carries the burden. You will find that is done in the best of railroad families when cash is tight.

We have a daily report of cash from the treasurer, showing the amount of cash received the day before from each source and also disbursements, for pay roll, vouchers and any other expenditures, and the balance is accounted for as deposited in designated banks. It carries additional information showing contingent cash liability of pay checks and vouchers that have been sent out and have not been cashed, and any other contingent obligations.

I have dealt with this question in a very general way, without any definite purpose other than to extend information, and if I have been able to contribute anything to your general sum of knowledge, I am very happy in having been with you today.

The Human Element in Fuel Efficiency

By H. S. Rauch, Superintendent, Motive Power, New York Central Railroad

The human element involved in any undertaking is only as efficient, loyal and enthusiastic as is the leadership under which they are working.

Interest and enthusiasm are infections and the rank and file are only "exposed" to the degree to which their leadership has become infected.

The conservation of fuel is no exception; executives of whatever rank cannot "wink" at violations of coal saving standards and expect efficiency from those to whom are entrusted the actual conversion of fuel into units of heat and power.

History of all activities, since the beginning of the world, shows that where the human element entered into any undertaking, success or failure was entirely dependent upon the type and quality of leadership.

You who are in positions of authority and upon whom rest the responsibility of economic operation of the Railroads with which you are connected, must first be thoroughly sold to this proposition of Fuel Economy. You must not only believe there is something in saving a pound of coal per passenger car mile or two pounds per 1,000 gross ton miles, but you must be enthusiastically sold to it—it must become an obsession with you before you can hope to successfully pass it on and sell it to those who report to you.

It should be remembered that not only the man who wields the scoop is responsible for fuel saving or lack of it—every officer and man from the presidents of our railroads down, have a part, and a most important one, to play; track layouts, elimination of grades, curves and dips; signals and signal maintenance; equipment and its state of repair; time tables governing operation have a most important bearing; even the lowly section man can waste fuel stopping trains unnecessarily; the inspectors of equipment, through carelessness, can cause vast waste of fuel by allowing work to get by which will cause delay on the road.

Train dispatchers, by making poor meets, can be a very prolific source of waste.

Baggage men and transfer men, expressmen, mail men holding trains unnecessarily, thereby causing loss of time which must be made up, cuts deeply into the coal pile.

The careless coal dock men who overload tenders; the slow switch tender who causes a train to come to a stop; the operator out on the road who is slow in handling of orders on territories operated by the Train Order System.

Steam leaks allowed to exist, careless power plant operators; lights burning when not needed, the so-called "standing" losses in fuel, where 25 per cent of the fuel consumed by American Railroads is burned at the present time, offers a wonderful field for economy in fuel practices.

Heavy fires brought in off the road resulting in a high coke content in the cinder pit; engines allowed to stand for long periods between receiving track and engine house; frequent pop openings; improper methods in fire cleaning and banking; mismanagement in making air and other tests requiring maximun steam pressure, necessitating breaking up fires once banked; lax supervision in properly banking fires, unnecessarily large quantities of coal used in firing up engines that have been dumped; firemen arriving early and preparing the fires for road service before leaving engine house territory, resulting in engine popping many times before reaching yard and train, all controlled by the human element. Indeed the vastness of opportunities for fuel conservation are almost beyond comprehension.

Bring this home to them with sufficient force and the results will be most gratifying to all who have been privileged to have a part in it.

In the final analysis, Fuel Conservation simply means better railroading and 100 per cent return for fuel consumed—means 100 per cent Railroad Operation, in all of which the human element is not only the most outstanding and of highest importance, but is the keynote to success or the loadstone of failure. Towering over all is the gigantic structure fabricated of human beings each member a unit in itself with power to think and to act in a manner individual and independent.

Having to deal then with many men of many minds, it is plain that a right viewpoint must be reached and all brought to envision the objective from that angle.

The stellar features required to bring this about are confidence, mutual respect, human understanding, "horse sense," and a working knowledge of the Golden Rule.

If you expect the highest type of service from a man, he must feel that you have confidence in his ability to perform that service; you must also show respect for his opinions and he, in turn, will have confidence in and respect for your desires.

Human understanding and "horse sense" together with an understanding of the Golden Rule simply make the formula with which to reach an efficient relationship.

Men cannot do their best work, as a rule, unless they are happy (there are few Edgar Allen Poes) and to be happy a man must feel safe, comfortable and have a reasonably bright outlook on the future.

No man employing labor can attain complete success unless he gives due consideration to the happiness of those in his employ, for happiness is the chief goal in human life, and one cannot attain it alone. Someone has truly said: "There is more happiness to be obtained in treating the other fellow to a plate of ice cream than in eating two plates one's self"—all of which leads up to the fact that success with the human element in Fuel Conservation requires a close personal contact with the forces using the fuel; a general understanding of their problems, both on the job and off; a desire to complete co-operation in doing your part in making working conditions as pleasant as the job will permit. Do not give an engineer an engine that is lame, blowing, leaking, or in any other manner seriously defective and expect he is going to have faith in your sincerity when you talk to him about black smoke or safety valves lifting.

You cannot practice back-hauling of cars; permit signals to be so operated as to stop heavy trains in bad places; make poor meets on single track lines or otherwise hamper train movements unnecessarily and expect train and engine crews to become enthusiastic over your program of Fuel Saving.

Give men your co-operation; show them you mean what you preach by being a practitioner thereof; make the job a game at which all play according to the rules, create a friendly spirit of rivalry—their objections will vanish, wholehearted interest will take its place and the results will be reflected in the coal bills.

Every man has more good in him than bad; if you have faith in him and appeal to that better part, he will have faith in you and you are sure to win him over and make of him a worthy ally.

All the ages and forces since form began to come out of chaos have given us two supremely good things—Opportunity and an Ideal worthy of it.

Third Class Sleepers in England

By R. W. A. Salter

It was stated in RAILWAY AND LOCOMOTIVE ENGINEERING last March that the British railroads, yielding to the force of public opinion, had been obliged to make arrangements for introducing third class sleeping cars. The first of these new sleepers are to be placed in service by three lines in the Fall of this year. They provide seating room for 56 passengers, convertible to sleeping accommodations for 28. The bodies of the cars are divided into seven compartments ranged along a side corridor. Each compartment has two upper and two lower berths, the former being turned upwards and locked against the partition when the compartment is to be used during the daytime. Separate lavatory and toilet compartments are provided at each side of the end vestibule doors at both ends of the car, and there are four washbasins for the 28 passengers. Blankets and clean pillowcases are supplied to each occupant of a berth, but no sheets; passengers are not expected to undress, however. The rate for a berth is 6 shillings ($1.44) in addition to the third class railroad fare, third class being equivalent, if the fares charged for such travel be taken as a basis of comparison, to first class in the United States. A view of the interior of a third class sleeping compartment is reproduced. Our British contemporary, "Modern Transport," describes these sleeping cars as "infinitely superior to the arrangements common to long-distance trains in America," but Americans, accustomed to clean bedding and to the privacy of a curtained-off berth, are not likely to agree with this.

Finds Traffic Volume Cuts Equipment Buying

Reduced purchases of railway equipment in recent years, according to Charles W. Foss, Railway Analyst, Adams & Peck, in an address before the New York Railroad Club, is due chiefly to the following three causes:

Increased utilization of existing equipment by the railroads.

Failure of traffic to incrrease in its former ratio.

Inability of the railroads to earn a fair return.

In his analysis, Mr. Foss pointed out that there has been only one year in the past nine in which locomotive purchases have exceeded 2,000, whereas in the preceding eighteen years there were only three years in which such purchases were less than 2,000. In the case of freight cars, it was explained that there has been only two years in the last nine in which orders have totaled over 100,000, while in the preceding eighteen years there were only three years in which orders fell under 100,000.

Examining the traffic aspects of this situation, it is readily admitted that "railway equipment purchasing will probably be in greater volume in years in which the railways have a substantial increase in their business, than in years in business of a decrease in the volume of tonnage.

"Prior to the war traffic tended to double about every twelve or thirteen years, thereby showing an average progressive increase of about 7 or 8 per cent a year. Detailed analysis shows that equipment purchases were larger in those years which produced new peaks of traffic volume, and correspondingly smaller in years which showed a lesser increase in tonnage or which showed decreases.

"Keeping in mind that, prior to the war, traffic used to double about every 12 or 13 years or increase on the average about 7 or 8 per cent per year, it is extremely interesting to observe the contrast since the war. The largest increase as between any two years since 1918 was between 1926 and 1925, when it was 7 per cent.

"Among the reasons that I ascribe as the cause of the failure of traffic to increase in its former ratio is the motor truck which moving on improved highways has undertaken the transportation of many ton-miles that formerly moved by railroad. The passenger motor car, strange as it may seem, may have eliminated much railway freight traffic. This follows because the motor-car passenger is speeded on its way by gasoline whereas formerly when he traveled by train, the power that transported him came from coal."

The fuel for motor transport—either passenger or freight—tends to move, not by rail, but by pipe line or tank steamer. I appreciate that every railroad secures a large and growing volume of refined petroleum tonnage, but I should also like to remind you that there are now some 90,000 miles of pipe lines in this country that are transporting a tremendous volume of transportation power units in the form of crude oil. Cannot this be said to have replaced to no inconsiderable extent the transportation of transportation power units in the form of coal moving by railroads that otherwise might be required for use in locomotives?

The railroads have made phenomenal savings in coal consumption per 1,000 gross ton-miles. Every ton of coal saved by their efforts in this direction is one less ton for the railroads to carry. I understand that the electrical industry has made even greater proportional fuel savings per unit of power produced than the railroads have. We must also take into consideration the production of hydro-electric power and the transmission of electric power by long distance transmission lines.

Railroad Safety Awards

Bronze plaques have been awarded by the National Safety Council to the seven railroads which had the lowest casualty rate during 1927 in each of seven groups arranged according to man-hour exposure.

This is the first award made by the Council under a plan for an annual contest which it has established for Class I railroads on the basis of the number of casualties—killed and injured—to railway employes on duty, in train, train service and non-train accidents, per million man-hours' work, according to the official records of the Interstate Commerce Commission.

Under the terms of the contest, as announced by the National Safety Council, the contesting railroads are classified under seven different groups in accordance with their respective annual man-hour exposure as follows:

Group A to include all units and systems having 100,000,000 or more man-hours.
Group B—50,000,000 to 100,000,000 man hours.
Group C—20,000,000 to 50,000,000 man-hours.
Group D—10,000,000 to 20,000,000 man-hours.
Group E—5,000,000 to 10,000,000 man-hours.
Group F—2,000,000 to 5,000,000 man-hours.
Group G—Less than 2,000,000 man-hours.

The Council explained that inasmuch as no awards were made in the past to the leaders of the various grups as published in the safety report of the Interstate Commerce Commission, it was decided that the initial award should include recognition of the previous safety accomplishments of these group leaders.

The Union Pacific System was the winner in Group A of 23 contestants, with the lowest total casualty rate, for five consecutive years. This total casualty rate of 7.89 (per million man-hours) for 1923 was reduced to 3.53 last year, a decrease of 55 per cent.

The Union Pacific Railroad was the winner in Group

B which had 19 contestants. For the year 1923 the casualty rate was 5; for the year 1927 it was 2.72, a reduction of 45 per cent.

The Oregon Shore Line was designated winner in Group C of 25 contestants. During the past four years the total casualty rate of this road was reduced 70 per cent.

The Los Angeles & Salt Lake was the winner in Group D in which there were 25 contestants. For the year 1923 the casualty rate of this company was 4.86 and for the year 1927 it was 3.24, a reduction of 3 3per ecnt.

The Duluth, Missabe & Northern was designated winner in Group E with 21 contestants. The casualty rate for the year 1923 was 7.79 as against 2.88 for the year 1927, amounting tc a reduction of 63 per cent.

The Duluth & Iron Range was the winner in Group F of 32 contestants. Having operated two consecutive years without fatality, and with a year by year decrease in injuries, this railroad has reduced its total casualty rate to 2.45 for the year 1927, a reduction of 77 per cent as compared with 1923.

The Baltimore, Chesapeake & Atlantic, the winner in Group G of 42 contestants, has a five-year clear fatality record. The average total casualty rate of 2.72 has been calculated against a cumulative exposure of 5,155,117 net man-hours.

In his introduction to the presentation of the awards, Homer E. Niesz, President, National Safety Council, pointed out that the safety work undertaken by the railroads in the past four years, with its resultant lowering of the rates of casualties, has meant the saving of the lives of 977 employes and a reduction of 119,000 in reportable accidents among railroad workers based on the 1923 rate.

Braking Power as Influenced by Non-Uniform Piston Travel

Great care and thoughtful consideration has been given to the subject of power brakes upon the rolling equipment of our American railroads, in an endeavor to provide for this mechanism a practical state of perfection. There are, however, certain fundamental principles of present triple valve construction and operation, together with the many items between the triple valve and brake-shoe, which merit more serious consideration. The improper functioning of a power-brake due to improper adjustments of the foundation brake-gear, seriously interferes with the final economic results, and nullifies to an alarming degree the uniform distribution of a brake effort proportional to the requirements of each car in a train.

The triple valve may functionate properly and the braking ratios to the wheel be properly calculated, with all parts in working condition, yet the desired results are seriously interferred with by reason of the fact that the triple valve and brake mechanism provide no means to compensate for "Piston Travel," which is largely influenced by brake-shoe wear and improper adjustments and wear, found in foundation brake-gear. These conditions not alone largely influence and annul a uniform build-up of brake cylinder pressure, but result in a wide variation in braking power in proportion to the gross load. They largely influence the "Push Rod" force for frictional shoe resistance between cars of the same class, or more particularly so, between cars of various classes. These combined influences tend to place the entire brake mechanism out of balance and are very expensive in the way of broken trucks, pedestals, deformed hangers, deformed brake-beams, excessive brake-shoe consumption, brake-burned and slid-flat wheels, break-in-twos, buckling cars and excessive damage to equipment and lading.

It is a long recognized fact, that there are gross irregularities in the braking power of various classes of cars having the same gross load, and it matters not how closely the recommended standards under the Master Car Builders' Rules are adhered to, the same variation remains. This is due to unequal braking power, caused by non-uniform piston travel. Under conditions where high cylinder pressures are not necessary, the same frequently obtained, due to changing piston travel. The coefficient of friction between the brake-shoe and the wheel are more nearly constant than that of the wheel and the rail, hence, the friction is greatly increased on cars having a short piston travel. The time interval in application and release of train brakes is an important factor, and where travel varies, cylinder pressures vary, therefore the time required to obtain and release cylinder pressures must necessarily vary in both application and release of train brakes.

It is commonly admitted that non-uniform piston travel is a primary cause for wheel sliding, and too much emphasis cannot attach to the evil effects produced by flat wheels upon rails and road-beds, neither can their bad influence be over-estimated with respect to safety and economy of operation. In the examination of flat wheels, it is frequently claimed that the spots are worn and not slid-flat wheels. This may appear correct to the casual observer, yet the actual facts are, that such wheel conditions usually have their origin in, and are the result of prior brake burned wheels. It is found that much less damage is done to wheels having a uniform braking power, which will maintain a uniform velocity on mountain grades by producing a retarding force, just equal to the gravity effect, and which will equalize and regulate the brake-cylinder pressure so that each car in a train will at all times bear its proportionate share of velocity resistance.

An example of the evils of non-uniform piston travel as obtained from a brake-pipe reduction of ten pounds, follows:

Based upon a standard piston travel of eight inches, for each inch the travel is increased, to and including eleven inches, the braking power decreased 16½, 33 and 44 percent respectively. For each inch the travel is decreased to and including four inches, the braking power is increased 20, 44, 58 and 130 percent respectively. This is conclusive that with the piston travel eleven inches, the braking power is forty-four percent less than that obtained with an eight inch travel, hence a difference of one hundred seventy-four percent in braking power as between cars having a four inch piston travel and those having a travel of eleven inches. Such conditions in the operation of freight trains result in constant expense to the carrier.

The greatest difference in brake cylinder pressure, due to irregular piston travel, is found in partial full-service brake-pipe reductions, and these are necessarily constant in train control. The initial brake-pipe reduction must be sufficient to guarantee brake action throughout a train, yet should not exceed ten pounds. Therefore, even though the reduction be continued to full service, practically all the damage results from the first or initial reduction. With the same type of triple valve the graduation port should have the same opening to the brake-cylinder and this means that the cylinder volume to be filled naturally varies in proportion to piston travel. Therefore, differing cylinder volumes, filled from the same port opening necessitate a wide difference in the time element to obtain cylinder pressures. Such conditions do not alone produce rough train handling which are beyond the control of the engineer, but also materially increase air-consumption which in turn means excessive fuel consumption.

In 1916, on page ninety (90) of the Proceedings of the Air Brake Association, is found a statement made by Walter V. Turner, one of the most noted and recognized airbrake authorities, which reads as follows:

"For adjustment of piston travel we should use the most simple device or mechanism and one that admits of easy access to the car repairer. I think if we could get an easy means for quickly adjusting piston travel and keeping it at eight inches (or that desired) a great part of our rough handling will be done away with. Therefore, wherever it comes from, whatever company or individual develops something that will tend toward an easy and rapid adjustment and maintenance of proper piston travel, that should be something you should look into and I should say, use it the first time you get an opportunity."

A fundamental requirement of smooth handling of trains is the maintenance of the desired cylinder volume, and that can be done only when the piston travel is kept constant.

Notes on Domestic Railroads

Locomotives

The Illinois Central Railroad has ordered one 600-hp. oil-electric locomotive from Ingersoll-Rand, Inc., and the General Electric Company.

The New York Central Lines is inquiring for 55 locomotives; 30 of the 4-6-4 type and 25 of the 4-8-2 type.

The National Railways of Mexico has ordered two 4-6-2 type locomotives from the American Locomotive Company.

The Manila Railroad has ordered 4 three-cylinder Mikado type locomotives from the Baldwin Locomotive Works.

The Mogyana Railway, (Brazil) has ordered two locomotives of the 4-6-0 type from the American Locomotive Company.

The International Railways of Central America have ordered 2 heavy Mikado type locomotives from the Baldwin Locomotive Works.

The Kwang Tung Yueh Han (Canton, China) has ordered two locomotives of the 4-8-2 type from the Baldwin Locomotive Works.

The Mexican Railway Company has ordered two Pacific type locomotives from American Locomotive Company.

The Denkmann Lumber Company has ordered one Mikado type locomotive from the American Locomotive Company.

The Colombia Railway & Navigation Company, (South America) has ordered one Consolidation type locomotive from the American Locomotive Company.

The Union Railroad Company is inquiring for two locomotive tenders of 7,000 gallon capacity.

The Missouri-Kansas-Texas Lines has ordered one 33-ton locomotive crane from the American Hoist & Derrick Company.

The Saginaw Logging Company, Saginaw, Michigan, has purchased one 2-8-8-2 type locomotive from Baldwin Locomotive Works.

The Delaware & Hudson Company is inquiring for one Decapod type locomotive.

The Chicago, & Illinois Midland Railway has ordered one 4-4-0 type locomotive from the Baldwin Locomotive Works.

The Cleveland, Union Terminals Company has ordered 20 electric locomotives from the General Electric Company.

The Central Vermont Railway is reported to have placed an order for eight locomotives with the American Locomotive Company.

The Alaska Railroad is inquiring for one Mikado type locomotive.

The Chesapeake & Ohio Railway will build 10 locomotive tenders in its own shops.

The Chicago, West Pullman & Southern Railway has ordered one six wheel switching locomotive from the Baldwin Locomotive Works.

Passenger Cars

The Reading Company is inquiring for two combination passenger and baggage gas-electric cars, three combination passenger, baggage and mail gas-electric cars and three trailers.

The Chicago Great Western Railroad has ordered three baggage and mail cars from the Pullman Car and Manufacturing Corp.

The Chicago, St. Paul, Minneapolis & Omaha Railway is now inquiring for 10 gas-electric rail motor cars.

The Canadian National Railways has ordered 3 steel combination baggage and mail cars from the American Car & Foundry Company. These cars are for service in the United States.

The Southern Pacific System has ordered one passenger and baggage gas-electric rail motor car, equipped with double power plant, from the J. G. Brill Company.

The Chicago, Burlington & Quincy Railroad will build 33 steel suburban passenger cars at its Aurora, Ill., shops.

The Alaska Railroad is inquiring for two second-hand or new passenger coaches.

The Pennsylvania Railroad has ordered 550 all-steel express refrigerator cars of new design. The order, amounting to approximately $5,000,000, was divided among four companies as follows: American Car & Foundry Co., 200 cars; Pressed Steel Car Company, 200 cars; Pullman Car & Manufacturing Corp., 100 cars; and the General American Car Company, 50 cars.

The Louisiana & Arkansas Railway has ordered one passenger and baggage gasoline rail car from the J. G. Brill Company.

The Missouri-Kansas-Texas Lines has ordered 19 baggage and mail cars from the American Car & Foundry Company.

The Oklahoma Railway Company is inquiring for from one to three pairs of passenger motor trucks.

The Northern Pacific Railway is inquiring for one steel business car.

Freight Cars

The Midland Utilities Company of Indiana, has ordered for the Chicago South Shore & South Bend, two 30-ft., steel underframe caboose cars, from the American Car & Foundry Company.

The Public Service Company of Northern Illinois is inquiring for 1 special flat car.

The Erie Railroad is now inquiring for 5 depressed center flat cars of 120 tons' capacity.

The Chicago & Eastern Illinois Railway has ordered 100 single sheathed automobile cars of 40-tons' capacity from the Mt. Vernon Car & Manufacturing Co.

The Chesapeake & Ohio Railway has placed orders for 500 steel hopper bottom gondola car bodies of 70 tons' capacity, as follows: American Car & Foundry Company, 200; Richmond Car Works, 300.

The Lehigh & New England Railroad has ordered 3 eight-wheel steel underframe caboose cars from the Pressed Steel Car Company.

The Illinois Traction System, Springfield, Ill., is inquiring for from 100 to 200 composite gondola cars, of 50 tons' capacity.

The Great Northern Equipment Company is inquiring for 2,500 freight cars and 2,000 steel underframes. Included in the inquiry are 500 50-ft box cars, 500 52-ft. flat cars, 500 40-ft. coal cars, all of 100,000 lb. capacity, and 1,000 all-steel ore cars. The underframes included in the inquiry will be for 80,000 lb. capacity box cars.

The Cities Service Company has ordered 10 tank cars from the American Car & Foundry Company.

The Chicago, Rock Island & Pacific Railway has ordered 10 air-dump cars from the Western Wheeled Scraper Company.

The Cuyamel Fruit Company, New Orleans, La., is inquiring for 75 banana cars.

The United States Navy, Bureau of Supplies & Accounts, has ordered 2 gondola cars from the Pressed Steel Car Company.

The Norfolk & Portsmouth Belt Line is inquiring for two steel underframes for caboose.

The Missouri Pacific Railroad has ordered 100 automobile furniture cars from the American Car & Foundry Company.

The American Railroad of Porto Rico is inquiring for 100 cane cars of 20 tons' capacity.

The Sanitary District of Chicago has received bids for 54 air dump cars, of 30 cu. yd. capacity.

The Nevada Consolidated Copper Company is inquiring for 20 Ingoldsby type ore cars, of 60 tons' capacity.

The United States Navy Department has ordered one tank car for carrying helium gas from the General American Tank Car Corporation.

The Illinois Central Railroad has bought two air dump cars from the Western Wheeled Scraper Company.

The Paulista Railway (Brazil) has placed orders for 1,000 freight cars with builders in the United States.

The Erie Railroad has ordered 100 steel furniture cars from the Magor Car Corporation; one air dump car of 30 cubic yard capacity from the Clark Car Company and one air dump car of 27 cubic yard capacity from the Differential Steel Car Company.

The International Railways of Central America have ordered 150 box cars from the Gregg Company.

The Norfolk & Western Railway will rebuild 500 90-ton steel gondola cars at its Roanoke, Virginia, shops.

The Cities Service Company has ordered four tank cars from General American Tank Car Corporation.

The American Oil Company, Baltimore, Md., has ordered one two-compartment tank car of 4,500 gallon capacity from the General American Tank Car Company.

The Barrett Company has ordered 16 class 105 tank cars of 50,000 lb. capacity from the General American Tank Car Corporation. These cars are to be used for carrying anhydrous ammonia.

The Argentine State Railroads divided an order equally between the Middletown Car Works and the American Car & Foundry Company, for 2,200 freight cars of various types and designs.

The American Cyanamid Company, New York, has ordered 25 covered hopper cars of 70 tons' capacity, from the General American Car Company.

The Carnegie Steel Company has ordered repairs to 16 hopper cars from the Greenville Steel Car Company.

The Chicago, Rock Island & Pacific Railway has placed 250 gondola car bodies and repairs to trucks with the Ryan Car Company.

Items of Personal Interest

J. W. Highleyman, who has been promoted to superintendent of motive power and machinery of the Oregon Short Line, with headquarters at Pocatello, Idaho.

J. P. Driscoll, master mechanic on the Erie, with headquarters at Little Ferry, N. J., has been appointed master mechanic at Secaucus, N. J., succeeding **L. R. Laizure**. The position of master mechanic at Little Ferry, N. J., has been abolished.

J. W. Burnett, master mechanic of the Wyoming division of the Union Pacific, with headquarters at Cheyenne, Wyo., has been promoted to assistant superintendent of motive power, with headquarters at Omaha, Neb. **John Gogerty**, master mechanic of the Western division, with headquarters at Green River, Wyo., has been transferred to the Wyoming division to succeed Mr. Burnett.

Thomas Hambley, assistant superintendent in the motive power and car department of the Canadian Pacific with headquarters at Winnipeg, Man., has been promoted to general superintendent of the Algoma district, with headquarters at North Bay, Ont., succeeding Andrew Halkett, who has been transferred to the Alberta district.

C. J. Bodemer, acting superintendent of machinery of the Louisville & Nashville, with headquarters at Louisville, Ky., has been promoted to superintendent of machinery, with headquarters at the same point.

Charles S. Giles, superintendent of machinery of the Louisville & Nashville, with headquarters at Louisville, Ky., has retired.

V. E. Mately has been made roundhouse foreman of the Gulf Coast Lines at Sugarland, Tex., vice **C. M. Wiles**, transferred to San Benito, Tex.

A. C. Wolk has been made general roundhouse foreman of the Missouri-Pacific Railroad at Houston, Tex., vice **P. T. Marquette**.

O. W. Bailey has been made road foreman of engines of the Missouri Pacific Railroad at Jefferson City, Mo., vice **J. A. Greig** transferred.

W. J. King has retired under the pension system of the company as blacksmith foreman of the Illinois Central Railroad at Water Valley, Miss.

Supply Trade Notes

The Ira J. Owen Organization, industrial engineers, has been formed with offices in the First National Bank Building, Chicago, to analyze, reorganize and operate industrial plants in the commercial and railway fields.

The Packard Electric Company, Warren, Ohio, has sold its transformer division to the **American Brown Boveri Electric Corporation**. The Packard company, transformer division, has made a wide range of transformers which will be continued in all types and sizes, under the established trademark Packard. The manufacturing and engineering facilities will be consolidated with those of the other departments of the American Brown Boveri Electric Corporatiosn Camden, N. J., plant. It is understood that **N. A. Wolcott**, president of the Packard Electric Company, will become affiliated with the American Brown Boveri Electric Corporation.

The National Accessories Company, with offices at 214 Harrison building, Philadelphia, Pa., has been formed by

J. J. Voigt, Jr., formerly of the E. A. Lundy Company, and P. M. Etters, formerly of the Thomas L. Mount Company, to deal in railway signal and electrical accessories.

Paul Mackall has been appointed representative of the **Bethlehem Steel Corporation** in charge of general sales, succeeding **E. S. Kinsley**, who has retired to less active duties.

The **Syntron Company**, Pittsburgh, Pa., has appointed the following district sales managers: **R. M. Hibbs**, at 1426 Fairmount avenue, Philadelphia, Pa.; **F. L. Johnson**, 2146 East Fourteenth street, Cleveland, Ohio; **William Heritage**, 3711 Delmar avenue, St. Louis, Mo.; **G. A. McKee**, 1759 West Forest avenue, Detroit, Mich.; and **C. W. Osborn**, at 2404 Main street, Dallas, Tex.

Harold S. Russell has been appointed representative of the **Southern Wheel Company**, with offices in the McCormick building, Chicago. Mr. Russell succeeds **A. K. Hohmeyer**, resigned.

The **A. M. Castle & Co.**, Chicago, has let a contract for a large addition to its present San Francisco, Cal., unit on Indiana street. The new bay is to be 70 ft. wide by 600 ft. long, and will be erected on the west side of the present warehouse. The building will be a steel frame structure with corrugated iron walls and roof. Two traveling overhead electric cranes will serve the bay.

The **Kearney & Trecker Corporation**, Milwaukee, Wis., are building a new three-story office building to adjoin their present office structure and provide increased facilities for offices that were formerly occupying shop area.

C. J. Olmstead, western manager, **Westinghouse Air Brake Co.**, with headquarters at Chicago, has been appointed assistant to the vice-president. He will be succeeded by **C. D. Foltz**, who has been assistant western manager. **A. K. Hohmeyer** has been appointed assistant western manager.

Max Epstein, president of the **General American Tank Car Corporation**, Chicago, has been elected chairman of the board, and will be succeeded by **Elias Mayer**, general counsel and vice-president.

The **L. B. Foster Company** has opened a St. Louis office at 1725 Railway Exchange building, Chicago.

A. F. Morris, vice-president and sales manager of the **Morgan Engineering Company**, Alliance, Ohio, has been elected president of that company. **S. F. Kallenbaugh**, assistant sales manager, has been elected sales manager and will be succeeded by **Tom J. Muir**, sales office manager.

William Hunter, acting manager of the **Niles-Bement-Pond Company**, with headquarters at Philadelphia, Pa., has been appointed manager of the Philadelphia office.

Grant Thorn, who recently resigned as sales manager of the American Cyanamid Company, has become associated with the subsidiaries of **International Combustion Engineering Corporation**, New York.

Elliott E. Van Cleef, 53 W. Jackson boulevard, Chicago, has been appointed district sales agent in the Chicago territory for the **Roller-Smith Company** of New York.

A. W. MacLean has been appointed a special representative of the **MacLean-Fogg Lock Nut Company**, Chicago.

J. Thos. Rhamstine, Detroit, Mich., has taken over the business of the **American Strombos Company**, Philadelphia, Pa.

The **Transportation Equipment Company**, Graybar building, New York, has been appointed sole distributors of **Hopkins Spray Equipment Company**, San Francisco, Cal., for all the railroads of the United States.

J. L. Lavallee has been appointed assistant manager of the railway sales division of the **Texas Company**, with headquarters at New York.

The **American Rolling Mill Company**, Middletown, Ohio, has awarded a general contract to **H. W. Cox**, Ashland, Ky., for the construction of a one-story storage and distributing unit 160 ft. by 270 ft. at Ashland to cost $175,000.

The **Reynolds Electric Company**, Chicago, has taken over the **Konectolite Company**.

H. A. Mullet, who has been elected president of the **Bradley Washfountain Company**, Milwaukee, Wis.

H. T. Heath, formerly sales engineer of the **Illinois Motive Equipment Company**, has been appointed representative of the **Timesaver Products Co.**, Chicago.

D. J. McCarthy, chief engineer of the **Chicago Railway Signal & Supply Co.**, Chicago, has been appointed vice-president and general sales manager. Mr. McCarthy succeeds **Charles O. Poor**, who resigned as vice-president and general manager at Chicago.

Raymond E. Miller, assistant chief engineer of the **Westinghouse Air Brake Company** at Wilmerding, Pa., has been appointed general engineer of the same company, succeeding the late F. H. Parke, who held that position for many years prior to his death last June.

Mr. Miller is well known in the railway industry through his connection with the Westinghouse Air Brake organization for the past twenty-two years.

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The Great Northern Electrification

Opening of New Cascade Tunnel—Longest in the Western Hemisphere Inaugurates 100 Per Cent Electric Operation Between Skykomish and Wenatchee.

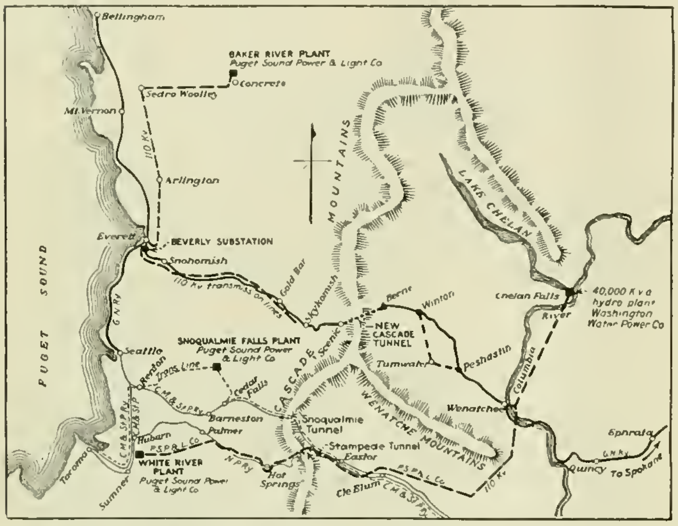
By P. A. McGEE, General Engineer, Westinghouse Electric & Mfg. Company

The driving of the new 8-mile Cascade Tunnel, and the relocation of lines through Chumstick Creek on the eastern slope of the Cascade Mountains represent only part of the important betterments recently completed on the Cascade Division of the Great Northern Railway. The electrification of the mountain section of the Cascade Division is in itself so great an improvement that it may justly be heralded as a development of the greatest importance. Train operation through the 8-mile tunnel on the 1.5 per cent grade, without the addition of artificial ventilation, would be impossible except by the use of electric motive power. The electrification of such a tunnel is, of course, imperative, and with the electrification of the tunnel, its extension to the limits of the heavy grade sections approaching the tunnel followed as a matter of progressive policy.

371-Ton Single Phase Motor Generator Locomotive and Train on the Great Northern Railway

The Great Northern Railway was a pioneer in the application of electric traction to main line railways. In 1909 they electrified the original 2¾ mile Cascade tunnel extending between Tye and Cascade. This electrification consisted of a 3-phase contact system from which two trolley pole collectors fed polyphase locomotives. The contact system had 6,600 volts between phases and consisted of two direct suspended trolley wires and the rail.

In 1926 the Great Northern Railway decided to extend its electrification to Skykomish at the Western base of the Cascade grade. It is significant that the railway management, in view of its previous experience with the high voltage, 3-phase system and with the desire of obtaining the advantages of high-voltage power transmission on the contact system together with the excellent characteristics of the d-c. motor for freight drag service on the heavy grade, specified an 11,000-volt single-phase contact line to be used with the motor-generator type locomotive. The Great Northern Railway today is the largest user of this



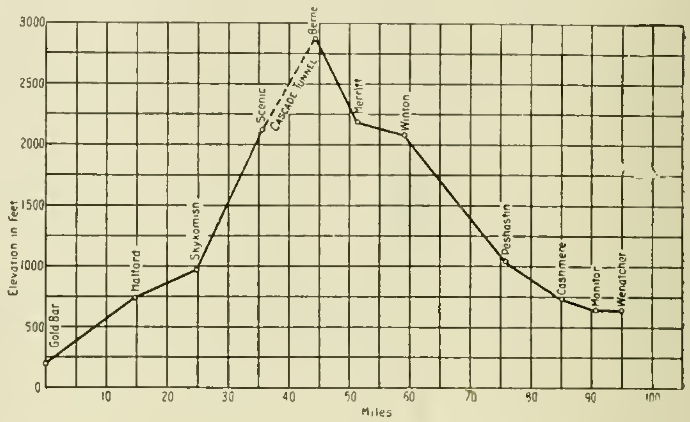
Map of the Electrified Section of the Great Northern

type of locomotive, and, in view of their two years' experience with motor generator engines in operation between Skykomish and Cascade, it is interesting to note the layout and characteristics of the system, together with some of the operating results obtained to date.

Supply of Power

Power for this 73-mile electrification is obtained both from the Puget Sound Light & Power Company's network and from the original power plant which supplied the 25 cycle, 3-phase power to the old tunnel. The map of the electrified section and the line diagram will readily explain the sources and arrangement of power supply. The Puget Sound, 110-kv. 60-cycle, 3-phase lines feed frequency changer stations at Skykomish and Wenatchee. The 60-cycle energy is converted by 7,500-kva. frequency changers, one in each station to 25-cycle single-phase power which is transmitted through two single-phase, 44-kv. circuits extending between Skykomish and Wenatchee. The Tumwater Hydro Plant is connected to this 44-kv. line and feeds in 5000-kva. to the system. The nominal total power capacity of the machines connected to the electrified section is therefore 20,000 kva. It is interesting to note that the original 25-cycle, 3-phase generators at Tumwater are now supplying 25-cycle, single-phase power.

There are seven distribution stations which convert the 44-kv. power to 11,000 volt supplying the trolley rail circuit. These stations are shown on the line diagram and are located on an average approximately ten miles apart. The total capacity of the converting transformers, including part of the 3-winding transformers at Skykomish and Wenatchee is approximately 30,000 kva. The distribution system is extremely simple in its layout and each of the transformer stations is controlled from a station agent's office, and the stations have been arranged with a view to such control. All oil circuit breakers at the transformer and main substations are electrically operated, and



Profile of the Great Northern Electrified Section

are arranged for full automatic relay protection. The distribution transformers are all arranged with inert-aire equipment From the capacity of the converting and distribution stations, it may be seen that the Great Northern is placing itself in an excellent position with regard to future possible increases in freight train size, with the accompanying increases in local power demand.

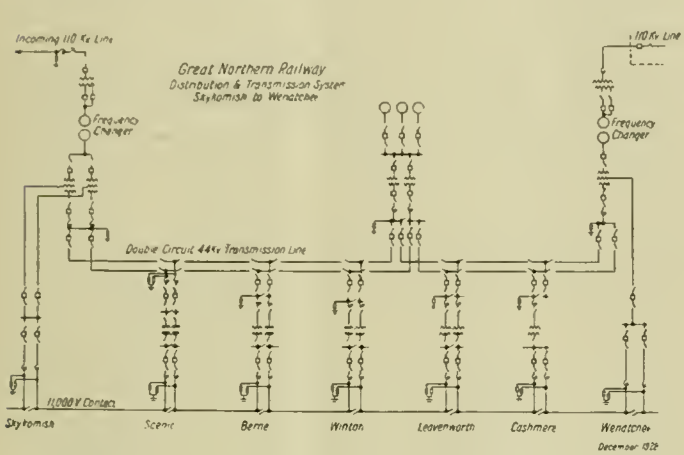
Contact System

The contact system employed represents the application of a much discussed type of overhead construction. The success of the initial construction between Cascade and Skykomish, where there is an unusual amount of curvature, much of which is ten degrees, has demonstrated the many economic advantages and satisfactory operating qualities of the simple inclined catenary system as furnished by the Westinghouse Electric & Manufacturing Company and employed as standard on this electrification.

The catenary system used comprises a cadmium bronze contact wire, supported by a composite messenger consisting of a bronze high-strength core surrounded by pure copper strand. The total equivalent conductivity is approximately 400,000 C.M. Hanger fittings and clamps to the messenger and contact wires are non-ferrous. On tangent track the contact wire is supported by flexible loop hangers, the messenger and contact wire being well bonded at 300 ft. intervals. On curved track up to 3½ degrees, pure inclined catenary is employed which permits the elimination of all pull-off devices other than the hanger supports. On curves of less radius than this, pull-off yokes are installed at the supporting poles, such curves employing arcs of 3½ degrees curvature with a maximum offset of 6 in.

On tangent track, 150-foot pole spacing is standard where the 44-kv. circuits are carried. The pole spacing between Winton and Leavenworth, where the transmission lines are not carried, is 180 feet. On curved track, the pole spacing is reduced on curves sharper than six degrees to suit a 6 in. maximum offset of the contact wire. Where possible, the contact wire height from the rail is retained at 24 feet. Through tunnels, and the limited number of snow sheds now existing, this height is considerably reduced.

Three standard Westinghouse type 601 insulators are employed to support the messenger on curves and on cross span construction. Pin insulators, type 3544, were extensively used with the 44-kv. transmission circuit. In the construction of the new 8-mile tunnel, provision was made by means of inserts at 75 foot intervals, to provide ample suspension insulator clearance so that, if necessary, a contact voltage of 22,000 volts eventually might be employed. By means of the inserts, maximum insulating distances are obtained without encroaching on the loading clearance of the tunnel. At suitable intervals, longitudinal troughs have been arranged in the tunnel for anchoring the messenger and contact wires so as to limit as much as possible any disarrangement of the catenary wire system.



Single Line Diagram of Great Northern Distribution System

The tensions in the contact and catenary wires are so related that, with inclined catenary, all hangers are parallel. This permits of an easy mathematical analysis of the catenary system and is, no doubt, in a large measure, an explanation of the very perfect geometrical arrangement of the wires which resulted on this construction. It is interesting to note that on the 16 miles of line extending between Winton and Peshastin where there is a considerable amount of curved track which does not, however, exceed three degrees—and where the structure spacing is practically uniform, there are no steady or pull-off devices attached to the contact wire on the main line.

With the excellent native wood poles used on this construction and with the well aligned and simple system employed, the contact system on the Great Northern Railway represents quite a contribution to the art of contact system construction as applied to main line steam railways.

Locomotives

The success obtained to date with this comparatively extensive application of the motor-generator type locomotive is the most interesting part of the electrification. These locomotives have already been described in previous issues and it is now a matter of interest to briefly review the two years' performance of the first two locomotives delivered to the Great Northern Railway by the Westinghouse Electric & Manufacturing Company early in 1927.

The single-phase contact system in the first instance extended between Skykomish and Cascade through the old 2¾-mile Cascade tunnel. The change from the 6600-volt, 3-phase contact system to the 11,000-volt single-phase contact system was made on March 5, 1927. Since that date all operation of trains over this limited length of track has been made with the motor-generator locomotives. The first two locomotives delivered maintained practically the entire service for nine months, and, in the first twelve months of operation, each locomotive covered over 50,000 miles on the 2.2 per cent compensated grade. To date, these locomotives are approaching their 100,000 mile mark, and when the condition of grade and limited speed of operation on this section is taken into consideration, it will be appreciated that this is a very creditable performance for a comparatively new type of locomotive in this exacting service.

With the extension of the electrification to Wenatchee, it becomes possible to exploit more fully the many inherent advantages of this type of locomotive. On the west slope of the mountain, the grade, as may be noted from the profile, consists of a steady 2.2 per cent compensated between Skykomish and Scenic. Through the new tunnel the grade is 1.56 per cent for 8 miles. On the east slope the grades consist of 2.2 per cent and .2 to .4 per cent, and a considerable stretch of track averaging approximately 1.3 per cent. With these varying grades, the advantages of being able to operate the locomotives at a


Catenary Cross Span Construction on Great Northern Electrification

constant horse-power output are apparent, both in the matter of the schedule speeds which can be obtained with limited maximum speeds, and in the matter of the maximun power demand resulting from a given schedule speed.

A locomotive starting at Wenatchee can, in either freight or passenger service, develop its rated hore-power on all grades exceeding .7 per cent. To obtain this desirable result, refinements in the control have been incorporated in these locomotives, which are of special interest. The locomotives can be operated with either a series characteristic such as that of the conventional d-c. motor, or as separately excited motors with either a constant speed characteristic or a constant horse-power characteristic. These varying characteristics are obtained through a closed circuit transition which permits of alteration in the circuits without any change in tractive effort or speed during the period of transition. The following table represents the general weights, dimensions and ratings of these locomotives:

Total weight	*742,200 lb.
Classification of wheels	1-D-1=1-D-1
Weight on drivers	569,600 lb.
Number of driving axles	16
Number of idle axles	4
Capacity at one hour rating	4330 hp.
Starting tractive effort, 25% adhesion	142,000 lb.
Maximum starting tractive effort,	33½%
Adhesion, limited by adhesion	189,000 lb.
Tractive effort—hourly rating	112,500 lb.
Speed—hourly rating	14.4 m.p.h.
Tractive effort—continuous rating	88,500 lb.
Speed—continuous rating	15.5 m.p.h.
Maximum speed	*45 m.p.h.
Track gauge	4 ft., 8½ in.
Total wheel base	62 ft., 10 in.
Rigid wheel base	16 ft., 9 in.
Length overall (between faces of buffers)	94 ft., 4 in.
Width overall	11 ft., 0 in.
Height from rail to locked position of pantagraph	15 ft., 10 in.
Diameter of driving wheels	56 in.
Voltage and type of conductor	11,000-volt, 1 phase, 25 cycle, overhead
Number and type of motors	16—type 356A
Method of drive	Double flexible gear
Gear ratio	18:91
Type of control	HBFR
Number of this type of locomotive in service	5
Year placed in service	2—1927 2—1928

* This data applies to locomotives 5000-5001, 5002-A—5002-B, 5007-A—5007-B.

Operating Conditions

The locomotive units, which may be assembled to operate with two or more units in multiple, are each rated to haul continuously 700 tons trailing load on a 2.2 per cent grade. At present, the customary arrangement is a locomotive made up of two units. Two such locomotives can take a 2,900-ton train either east or west on the 2.2 per cent grade approaching the tunnel. Two to four full tonnage eastbound freight trains are handled per day with somewhat lighter trains westbound.

Normally, three through passenger trains go east and west per day with many extra trains during the tourist season and occasional express trains with silk shipments from the Far East. Each passenger train will have an automatic train heating tender attached to the locomotive. The maximum weight of passenger train will be over one thousand tons.

The locomotives described can be interchanged readily between passenger and freight service and although predominantly drag freight engines they can perform a very creditable schedule in passenger service. For local service on this division a 50-ton locomotive and an electric motor car are being equipped.

The maximum power demand with one freight train is approximately 7,500 kw. This load may be increased to 9,500 kw. and it is expected to keep the maximum power demand for the system to approximately 13,000 kw. under present conditions of traffic. The local power demand of a 3,500-ton freight train will be 9,500 kw. This may be increased to 11,500 kw. with a 4,200-ton train and the distribution system is laid out to handle even heavier loads economically when the railway management requires it.

The electrification as installed provides for the unrestricted development of railway operation on this important division, both in the matter of freight train size and speed and in the speed of passenger trains. The distribution scheme can also be readily adapted to further extensions of the electrification. With power supply from three independent sources the continuity of service is assured.

For this electrification the Westinghouse Electric & Manufacturing Company has furnished ten locomotive power units, the last two of which will be delivered in January; primary requisites of the distribution system. including transformers and switchgear; and important features of the overhead contact system.

The operation of this important development will be closely followed by all those interested in railroad electrification.

French to Standardize Color Signals

The French Minister of Public Works is studying a project entailing the complete national standardization of the colored signal lights used on French railroads, based on a plan submitted by the French Railway Cummission. The plan involves the use of three clearly-defined colors; green, red and yellow-orange. indicating respectively "track-clear ahead," "stop," and "warning, slow down." It is proposed to keep all signals illuminated night and day. Up to the present time the use of signals has varied from one French railway to another. A national standard for all railways has long been sought and the present project represents the initial step toward a much needed reform. The actual changes to be made throughout France presumably will require a period of from 5 to 6 years to complete.

Committee Reports to the Mechanical Division of the American Railway Association

Lubrication of Cars and Locomotives

While the hydrostatic lubricator with single or double piping is in most general use, the force feed or mechanical lubricator is being used extensively. It has been found that the mechanical lubricator provides more efficient feeding of oil to the valves and cylinders, thereby prolonging the life of valve rings and bushings, and piston rings and bushings. To obtain economy in the amounts of oil consumed, as compared with hydrostatic lubricators, it is necessary to provide a variable feed through a proper connection of the ratchet lever connecting rod, so that as the cut-off is lengthened, the amount of oil fed per revolution of the driving wheels is increased.

Side and Main Rod Bearings

Grease is in general use for side and main rod bearing lubrication, with oil for valve gear bushings and pins. A number of lines are experimenting with a pressure system for side and main rod bearings and motion work lubrication. Reports indicate this system has given satisfactory results, and is an improvement over the old style rod cup for crank pin lubrication, and oil for motion work.

Guides and Piston Rods

Light oil, fed by gravity, is used most for guide lubrication, and properly designed oil cups and oil of proper consistency are important factors in successful lubrication. Some roads are experimenting with connecting feeds from mechanical lubricators to guides, thus lubricating them with valve oil. Reports indicate this method as satisfactory and more efficient than the oil cup method. Some roads, claiming the pistons secure sufficient lubrication from the cylinders, have eliminated piston swabs. An objection to the piston swab is that it might deceive the locomotive man into believing that the cylinder is being lubricated properly when it is not.

Locomotive Trucks

Two general practices are followed in packing locomotive truck cellars, viz., placing the packing in rolls with the ends turned under, or applying in one mass with the ends turned under. These methods appear equally satisfactory. A new departure is being tried with a bearing similar to that of floating bushings used in main rods, the halves of the bearing being bolted together, with the flanges forming the hub liner, and the bearing floating in the box. A grease cup is installed on the truck box, and journal compound is forced to the bearing in a manner similar to that used on ordinary rod cups. Where truck frames with outside bearings and boxes can be applied, they are proving more satisfactory than the inside bearings. Experiments show that where oil holes are drilled straight through the top of locomotive truck brasses, the tendency is for the oil to be forced back out through the top of the brass instead of following around the bearing. Proper results are secured by eliminating the holes and providing oil channels leading around the side of the brass, so that oil poured on top will flow into the cellars and then be fed from the packing.

Driving Journals

Grease is used most generally. Most roads use 3/16 in. holes in the perforated plates on road locomotives, and ⅜ in. holes on switching locomotives, but, with the dehydrated grease being used, some roads find that, by reducing the size of the holes from 3/16 to ⅛ in., and allowing a maximum of 50 lb. follower spring tension when the spring is fully compressed, grease consumption is reduced materially. Some roads are using improved designs of driving box cellars, with reduced contact surface of grease on journal, to reduce the grease consumption.

The method for many years to provide shoe and wedge lubrication has been to cut grooves in driving box or wedge, and drill holes from oil pockets in top of box to shoe and wedge faces, the oil pockets being packed with saturated waste. To provide more efficient lubrication, some roads have removed the saturated waste, welded a plate over oil pockets, applied to pressure fitting, and use a soft grease for lubrication. Reports from them indicate this method has proved satisfactory. In some instances grooves have also been drilled from these pockets to hub plates.

To prevent hot driving boxes, resulting from driving brasses gripping journals due to expansion, driving brasses should be bored sufficiently larger than journals to allow for expansion. The bottom edge of driving brass should be chamfered to assist the feeding of the grease.

Some roads have found that economy results by turning all driving journals when a locomotive receives general repairs. The committee believes this to be good practice.

Hubs and Hub Liners

The committee believes that the practice of lubricating these surfaces by pouring oil on them, at terminals or on the road, is not fully efficient under present operating conditions. Experiments indicate that welding a plate over the oil pockets on driving boxes, connecting to hub plates with an oil hole, applying a pressure cup in the top of the plate, and using a soft grease, provides more efficient lubrication.

One road reports the use of heavy graphite grease on locomotive trucks and trailers, together with floating hub liners, to have materially reduced wear. A hole is drilled through the locomotive truck wheel hub, and the grease is forced through this to the hub plates with a threaded plug similar to that used on rod cups. On the trailer boxes that were originally cored with oil channels leading to hub plates, pressure cups have been applied to the boxes, and grease is forced through oil channels to the hub plates. The floating hub liners on both locomotive trucks and trailers are perforated so that grease forced to them passes through and lubricates both sides of hub liner.

Trailer and Tender Boxes

Tender and trailer truck boxes without removable cellars should be packed like freight and passenger car journal boxes, as shown in the accompanying plan in the report dealing with cars, which is reproduced further on herein. Trailer truck boxes with removable cellars should be packed like locomotive truck boxes. Some roads have eliminated the holes through the top of the trailer truck brass, and provided oil channels leading around the sides of the brass, so that any oil poured on top will flow into the cellars, and then be fed from the packing to the bearing.

General

The committee feels that substantial progress has been made in the development of improved lubrication methods in recent years, and recommends that a continued study be made of this art.

Cars

The committee was instructed to give attention to specifications for packing of journal boxes, lubricating oils, oil reclamation, and waste for journal box packing, and it submitted the following recommendations for adoption as standard practice in connection with rule 66, also recommending that all work performed under rule 66 conform to these standard practices to justify billing for it: method of packing journal boxes; specifications for dust guards; packing tools for journal boxes; specification for reclaimed oil; specifications for new waste for journal box packing; inspection of journal boxes.

The method of packing journal boxes, as proposed by the committee for standard practice, gave detailed instructions for the preparation of both new and renovated packing, and then said: Before packing a journal box, the oil cellar shall be thoroughly cleaned of all dirt, sand, scale and grit, and if water is present it must be removed. When new journal boxes are applied, or when re-applying boxes, the interior of the box, including the dust guard well, shall be so treated, and close fitting dust guards and box lids complying with A. R. A. specifications shall be applied. Boxes shall be inspected for cracks which might cause oil leakage. In packing a journal box, insert a back roll and work it back under the journal to the extreme back part of the box, as shown at A in the accompanying plan. Make sure that the roll is well up against the journal, so as to properly lubricate the fillet at the end of the journal and to keep out the dust. The three inch rolls will insure better contact than a smaller size. The lengths of the rolls must be made to suit diameter of journal and such that ends shall not extend within less than ½ in. or more than 1 in. of the center line of the journal. Rolls should be prepared at a central point to insure a uniform and proper product. To form the roll, the necessary amount of dry packing is laid on a flat surface, and then rolled to length for a given journal, properly twisted and then wound with twine (3 ply jute; No. 18 B. C. flax, or mail twine are suggested), and tied to hold its shape, or spun on a spindle—in which case it is not necessary to be tied. If twisted, too tightly, roll with glaze quickly. The roll is to be soaked in oil and drained the same as other packing. Before applying journal bearings, they shall be thoroughly clean and be bored or broached to a proper contour in order to secure a uniform bearing on the journal and to remove irregularities, also to detect imperfections in the lining. Under no circumstances shall a relined bearing be used unless at least a 1/32 in. cut has been taken by boring the shell before it is tinned or relined. In relining bearings, no shell shall be used that is below the A. R. A. condemning limit of thickness. Under no circumstances is it permissible to use sand paper, emery paper or emery cloth to remove irregularities from the bearing surface. If necessary, a half-round file or scrape may be used. Journal bearings having lining loose, cracked, broken, spread over the side or worn to the brass, shall be removed. When applying or replacing a journal bearing, a coat of lubricating oil must be applied to its bearing surface.

The stock of prepared rolls, properly soaked and drained, should be kept at oil houses and issued to the packers as needed. In applying the body of the packing, first wipe off front of box, then apply sufficient packing preferably in one piece, to firmly fill the space B under the journal as shown in the plan, so as to prevent settling away, care being taken to have packing bear evenly along the full length of the lower half of journal. This is best accomplished by placing the packing across the full width of the mouth of the journal box, and allowing the strands to hang down outside, always adding more packing before placing the hanging strands inside the box. This has the effect of binding all the packing in one mass. The top of the packing should be 1 in. below the center line of the journal, along the sides, to insure against waste rolling under the bearing. By placing the packing under the journal until the front or outer edge of collar is reached, the front end of the packing then presents an inclined surface toward the front of the box. No loose ends or threads should protrude at the sides or ends, such ends being carefully tucked under the sides of the packing; nor should any pieces of packing be laid along the side of journal, as such pieces may become caught under bearing and cause a hot box. Front plug or dirt seal is not recommended but may be added if so desired, and will not be considered a violation of standard practice.

Car Construction Committee's Report

The car construction committee reported that as in immediately preceding years, it had delegated the assignments given it to sub-committees, the reports from which were incorporated in the report. The sub-committees dealt with fundamentals of car design; single sheathed and double sheathed box cars; stock cars, self-clearing hopper cars; refrigerator cars; cast steel truck side frames; truck springs; journal boxes and wedges; platform safety chains for passenger equipment cars; method of attaching brake beams to side frames; lumber sections; flat car stake pockets; definition on designating letters for cars; dimension marking for cars; axle wheel seat; recommendations for maintenance of arch bar trucks; automobile cars. The report, embracing the reports of the various sub-committees, was illustrated by a large number of drawings and photographs.

The sub-committee on fundamentals of car design stated that it had been instructed to revise the calculations for the single sheathed box cars in accordance with changes which have been made in some fundamental dimensions, viz., increase in end sill overhand from 5 to 5½ ft., increase in underframe width from 8 ft. 9 in. to 8 ft. 9⅝ in., and increase in thickness of floor plank from 2¼ to 2⅜ in. It reported that while its work had been delayed at the start by the necessity for revision of the original calculations, it was proceeding satisfactorily, and that it could be stated definitely that the changes in dimensions will not necessitate any alterations in the sections of the various side framing members of the cars. The report added: "Attention is directed to the fact that the underframe deflection calculations have been omitted from the revised report for the reason that they involve a great amount of additional work, and, even though revised, would not affect the conclusions originally reached, viz., that unyielding supports may be safely assumed, and that the crossbearers should be located at the door posts."

Automotive Rolling Stock Report

The committee on automotive rolling stock, of which C. E. Brooks, Chief of Motive Power, Canadian National Ry., was chairman, and of which B. N. Lewis, Mechanical Superintendent, Minneapolis, St. Paul and Sault Ste. Marie Ry., was a member, stated, in the introduction to its report, that the trend toward electric transmission, noted in its 1927 report, continues, as a consequence of which the 1928 report is confined to equipment using the electric form of drive. The Association's Motor Transport Division was organized in 1927. Its scope of activities includes motor rail cars, and in order to obtain the greatest possible co-operation between the two divisions, Motor Transport Division representatives were invited to attend the automotive rolling stock committee subcommittee meetings. It has been suggested that the best results can be obtained by joint efforts in the consideration of mechanical matters pertaining to all motor equipment, whether operated on rails or highway, and mention is made of this so that some definite arrangements can be made to this end before the committee's next report is submitted.

The report is confined to the power equipment of rail motor cars, including engine and transmission equipment, and the all-important questions of reliability and serviceability. It may appear to some that there is a lot of trouble with motor rail equipment, but the committee's findings indicate the opposite, and that excellent progress is being made in securing reliability. Suggestions that specifications for various sizes of power plant be prepared, were felt to be unwise, as rail car equipment is in a state of development, and changes and improvements are being made constantly, and anything in the way of attempted standards specifications would be more of a hindrance than a help.

Three kinds of fuel are in general use with rail motor equipment, viz.: gasoline, distillate and fuel oil, and at present there are certain inherent advantages in the use of each kind of fuel, all of which should be given study by users of automotive equipment. Information indicates that good progress is being made in the use of both distillate and fuel oil, and attention should be paid to the possibilities of economy with these lower grade fuels. The accompanying table 1 gives a summary of operating data for representative runs of gasoline, distillate and Diesel rail cars.

The serviceability of motor rail cars compares favorably with steam power, and approaches the standards set by straight electrical equipment. While statistics given in table 2 are representative of current conditions, lack of experience on the part of shop personnel and maintenance forces, insufficient supplies of repair parts and the necessity of making or applying certain design changes has tended to augment the number of days spent in the shop. This effect is partially, though not wholly, offset by the fact that, due to the newness of most of the equipment, relatively few general overhaul jobs are covered by these statistics. Attention is called to the fact that rail car equipment can be kept almost continuously at a high standard, by replacement of minor parts when worn, and that heavy rebuilding, as in the case of steam locomotives where the replacement of many major parts may be required, has no parallel in rail car operation.

Reliability.—Table 3 gives representative statistics showing the miles per delay of five minutes or more, and the miles operated per total failure. Practices for recording such data vary somewhat between different railways, so that these values are not necessarily strictly comparable. An analysis of the distribution of causes for engine failure between certain of the major units is given in table 4. A considerable majority of the delays experienced seem to be chargeable to accessories and auxiliary equipment rather than to the engine proper. It is decidedly gratifying to note from this information that the engines now in general use in rail cars are relatively free from inherent structural weaknesses. Many of the causes of the failures recorded have since been corrected, so that a continued improvement and, ultimately very high standards of reliability, may be expected.

Discussion of Engine Problems—Crankshafts.—Breakage of crankshafts is practically eliminated and causes no concern. Wear of crankpin bearings, while not excessive, contributes substantially to engine maintenance expense. Table 5 is submitted as an index of this condition.

Bearings.—Wrist-pin bearings have given no trouble except in isolated cases when improper fittings were responsible for incorrect clearances and alignment. Connecting rod big end bearings are reported as running 60,000 to 100,000 miles before tightening or replacement. After long use there are frequent occurrences of cracking of the bearing metal and separation from the bronze shell. This characteristic was especially noticeable in the case of certain experimental bearings, in which steel shells were used, in which case failure usually occurred at about one-third of normal mileage, and resulted in scoring of the crankpin. Small bolts or excessive strain on nuts contribute to these difficulties. It is appreciated that, in addition to proper lubrication, it is essential that bearing shells be very carefully fitted into the rod ends, and caps, that the caps must be tightly fitted and bolted to the rods, and that the crank and wrist-pin bearings be strictly parallel. Main crankshaft bearings are practically free from trouble except in the case of failure of the lubricating system or of the retaining dowel. Camshaft and timing gear bearings have in several cases given trouble by seizing and wearing prematurely. This seems to have been caused in some cases by misalignment, insufficient lubrication, and inadequate fastening and support of the bushings.

Complete lubrication is the determining factor in fixing the overhaul costs and the ultimate life of rail car power plants. Proper lubrication comprises: 1. An oil of the proper physical and chemical characteristics. 2. Maintaining a film of this lubricant intact at all times at points of potential wear. 3. Maintaining integrity of the lubricant by excluding or removing foreign matter such as diluents, sludge, abrasives and corrosives.

The obstacles to the realization of these conditions are numerous. An oil viscous enough to protect a hot engine under heavy load, may circulate so slowly through a stone cold system as to permit excessive wear before proper lubrication is fully established and vice versa. This condition is being met by pre-heating the engine by the car heating system by by-passing the radiators, or otherwise accelerating the warming up process. Conversely, if oil coolers are used to lower the maximum temperature of the lubricant, a lighter oil may be found to give satisfaction. Some operators have found that the indication of the oil pressure gauge on a cold engine might be entirely misleading, due to improper location of the gauge line, which showed pressure at the pump rather than at the most remote bearing. The early access of oil to other parts than crankshaft

TABLE 1. TYPICAL OPERATING CONDITIONS, GASOLINE, DISTILLATE AND DIESEL-ELECTRIC RAIL CARS; SUMMARY OF DATA FOR REPRESENTATIVE RUNS

Miles	Station distance miles	Train weight tons	Rated engine power	Average speed m.p.h.	Average output k.w.	Average engine h.p.	Max. engine output h.p.	Average k.w. per ton	Average miles per gall.	Ton miles per gall.	K.w. hours per gall.	Watt hours per ton mile	Average h.p. =% rated h.p.
						Diesel							
307	6.1	82.8	300	29.5	102	147	415	1.25	2.21	259	9.0	35.0	49.0
218	7.1	136.0	320	33.0	118	170	275	.87	2.16	259	7.7	30.0	{ 38.2 53.0
18.8	2.1	71.5	120	26.0	40.5	58.5	99.5	.57	1.40	87	2.2	25.0	{ 29.8 48.8
						Gasoline							
61.6	3.6	55.0	250	25.8	76.6	114	244	1.39	...	..	..	55.0	45.6
150	5.3	55.0	250	36.9	94.5	141	229	1.72	1.57	86	4.0	46.0	56.4
149	3.7	55.0	250	33.3	91.4	136	240	1.66	1.45	80	3.8	48.0	54.6
86.6	4.8	55.0	250	35.8	92.7	138	225	1.69	1.79	99	4.8	47.0	55.1
244	7.6	55.0	250	37.4	90.8	136	233	1.65	1.84	102	4.5	44.0	54.6
37.6	2.5	55.0	250	27.2	80.3	120	229	1.46	2.00	110	5.8	53.0	48.0
106	3.9	55.0	250	29.0	78.7	118	238	1.43	2.05	113	5.5	49.0	47.1
137	4.3	55.0	250	33.8	91.7	137	259	1.67	1.69	93	4.8	52.0	54.7
122	3.8	96.7	250	35.7	127.0	189	201	1.31	1.57	150	6.1	41.0	75.5
122	4.2	96.5	250	33.4	108.0	162	186	1.12	1.46	141	5.3	38.0	64.4
228	4.1	101.0	250	36.3	123.0	184	211	1.21	1.79	180	6.8	38.0	73.5
228	4.0	99.2	250	33.6	126.0	188	214	1.26	1.39	137	5.8	42.0	75.5
186	3.5	94.7	250	30.0	102.0	153	173	1.07	1.76	166	6.7	40.0	61.4
						Distillate							
135	7.3	68.7	225	26.7	....	...	...	...	2.0	137	..	...	...
225	7.2	111.0	275	24.1	....	...	...	...	1.5	166	..	...	...
225	7.2	85.5	275	26.4	....	...	...	...	1.5	128	..	...	...
68	5.7	75.7	225	29.0	....	...	...	...	1.9	142	..	...	...
68	5.7	77.6	225	29.0	....	...	...	...	1.7	130	..	...	...
95	6.3	81.9	225	27.7	....	...	...	...	1.9	156	..	...	...
132	6.6	113.0	225	25.3	....	...	...	...	1.9	205	..	...	...

TABLE 2. RECORDS OF PERFORMANCE IN REGARD TO SERVICEABILITY

	Gasoline						Distillate	Diesel
	A	B	C	D	E	F	G	H
% Unserviceable due to engine	3.4	15.0	...	1.9	3.2	...	...	16.7
% Unserviceable due to other power equipment	3.2	11.6	...	0.4	3.9	...	...	4.2
% Serviceability complete power plant	93.4	73.4	83.6	97.7	92.9	84.7	93.7	79.1

and cylinder walls is found to be of importance, because many of the cam and valve mechanisms and accessory drive bearings are not readily tightened, and the accumulated wear of these parts contributes in the long run to high maintenance charges or the gradual disintegration of the power plant.

Whatever the characteristics of the oil as originally supplied to the engine, they immediately begin to undergo changes in use, not, in the case of high grade oils, because of any appreciable breaking down of the oil itself, but because of the admixture of unburned fuel and the products of combustion. In gasoline engines, especially while warming up, a certain proportion of the heavier fuel fractions work past the piston and dilute the lubricant. Fortunately, in rail car service, the operating temperatures are usually high enough to prevent the accumulation of more than 15 percent of diluent. This diluent does no particular damage other than thinning down the oil from its original consistency; but because oils are used longer in the diluted than in the pure condition, this necessitates allowing for dilution in the original specification of the oil, and a resultant excess of viscosity immediately following the filling of the crankcase or oil tank.

Dilution is a much more serious problem when distillate fuel is being burned. In this case, the fuel fractions are so heavy, and accumulate so rapidly, that instead of stabilizing in the neighborhood of 15 per cent as in the gasoline engine, dilution reaches 40 to 50 percent within a few hundred miles of operation, and would apparently continue to increase indefinitely. At this point,

Table 3. Records of Performance in Regard to Reliability, Miles per Delay and per Failure

		Due to engine		Due to other power equipment	
		Delay	Failure	Delay	Failure
Diesel—	A.....	14,200	21,300	12,300	29,200
	B.....	44,312	310,184	12,984	77,546
	C.....	219,564	219,564	109,782	219,564
Gasoline—	D.....	57,100	85,700	.....	85,700
	E.....	31,800	63,600	22,400	51,800
	F.....	18,600	11,600	16,000	24,000
	G.....	00,000	00,000	00,000	00,000

however, even though an extremely heavy oil is originally supplied, the viscosity of the mixture becomes so low as to require draining and refilling of the system. As an example of this practice, it may be mentioned that although the oils usually used in gasoline engines for rail car service have a viscosity of about 75 seconds Saybolt at 210 deg. F., and a re-run with a crankcase temperature of approximately 140 deg., it has been found advisable when using distillate fuel to use oils which have an initial viscosity when new of 115 seconds Saybolt at 210 deg. and to cool them while running to 100 deg. F., or as near that temperature as possible. Dilution does not appear to an appreciable extent in Diesel engine lubricants. Rapid wear of piston rings and the upper end cylinder walls is apt to accompany excessive dilution, for it is at these points that the diluent is present in the largest proportions.

Carbon in the crankcase appears to come from two sources and to be of two varieties. Some results from the carbonizing of oil on the lower side of a hot piston head with the formation of hard grains or flakes, while some forms as smoke, due to incomplete combustion inside the cylinder, and a portion of this finds its way past the piston into the crankcase. The former variety is relatively coarse, and may be removed by filters connected to the lubricating system. The latter is extremely fine, tends to remain in suspension, and is not readily removed by filtering. It is more noticeable in Diesel engines than in other types. This carbon tends to clog piston rings, which in turn aggravates the rate of collection. In the presence of water, coming either from cooling system leakage or condensation of the products of combustion, carbon forms a slimy sludge which tends to clog screens, filters, and in some severe cases even oil passages.

The presence of abrasives may be minimized by careful handling of oil prior to putting it in the engine, rigid cleanliness when working upon the engine, and suitable location or shielding of the engine air intake.

Corrosion of steel parts, such as bearing surfaces and cam faces, results from sulphur acids in the crankcase. These acids are not present in new oils but form rapidly from the combustion products of high sulphur fuels if these are allowed to condense in the crankcase. High running temperatures and ample ventilation through crankcase and valve chambers will remove these products as vapors, and minimize their harmful effects.

Table 4. Analysis of Engine Troubles

	Number Failures	Per cent
Crankshaft	0	0
Bearings	7	5.9
Lubrication	9	7.6
Connecting rods	7	5.9
Pistons	4	3.4
Piston rings	0	0
Cylinders	1	.8
Cylinder heads	13	11.0
Valves	9	7.6
Valve mechanism	10	8.5
Cooling system	14	11.9
Fuel system	13	11.1
Ignition	3	2.6
Control	28	23.7
Total	118	100.0

Pistons occasionally give trouble, due to breakage through the ring grooves, for reasons not thoroughly understood, but very likely due to insufficient metal, too small clearance on the upper bands, or carbonizing in the ring grooves. Piston wear is not appreciable except for widening of the upper ring grooves. In some cases growth of the aluminum alloy pistons results in actual increase of size with use. Piston clearances have an important effect on oil consumption, particularly when idling a cold engine. Split skirt constant clearance pistons appears to alleviate this condition, though in some cases they have been found lacking in strength.

Ring groove clearance in the gasoline engine using aluminum alloy pistons is reported as follows after 75,000 miles operation:

Top groove......	.010	.012	.010	.012	.010	.012
2nd "	.002	.004	.006	.005	.003	.005
3rd "	.003	.004	.003	.003	.003	.002
4th "	.003	.003	.003	.003	.003	.003

These rings when new presumably had about 0.002 clearance.

Piston Rings.—Carbon formation in ring grooves results in stuck and broken rings and consequent rapid cylinder wear, oil pumping and oil contamination. With the exception of engines burning distillate, ring wear does not seem to be important, the chief wear occurring in the sides of the groove as mentioned in the preceding paragraph. Excessive groove clearance accentuates oil pumping. Various types of special oil control rings are being tried with varying degrees of success, in reducing oil consumption and preventing the fouling of spark plugs. Rings appear to have a life of 75,000 to 100,000 or more unless they are allowed to become stuck or broken.

Cylinder Sleeves.—Data on cylinder wear are incomplete and sometimes contradictory. Many sleeves have been replaced or reground at 25,000 to 60,000 mile intervals, while others have given satisfactory service for 100,000 to 160,000 miles. Normal average wear in 8¼ in. Diesel cylinders is reported as 0.010 in. in 100,000 miles, which may be increased to as much as 0.015 in. in 25,000 miles if the rings become blocked with carbon. In a 7¼ in. gasoline engine, without oil filter and changing oil every 2,200 miles, the wear at the bottom of the sleeves was about 0.002 in. and at the top averaged 0.008 in. parallel to the shaft, and 0.012 in. transversely, after 75,000 miles of service.

Rubber seal rings at the joint between the cylinder sleeve and the water jacket have given trouble on several roads and on different makes of engines. Leaks develop at the point, which require the removal of cylinder heads, pistons and cylinder sleeves to permit the application of new seal rings. It is suggested that rings of better quality might be developed, that two or more rings per cylinder can be used to advantage, or that a gland ring might be provided to permit the changing rings without dismantling the engine. One engine equipped with triple rings is the only type reported as being free from leakage difficulties.

Although not as yet resulting in the actual failure of cylinder sleeves, pitting of the other surface by electrolytic action of the cooling water has in some cases progressed to a depth of ⅛ in., and steps to minimize this action are in order. One road has found that the addition of about 3 oz. potassium bichromate to 100 gal. of cooling water appears to stop such pitting and to prevent the formation of rusty sludge and the plugging of water passages.

Cylinder Heads

The failure of cylinder heads has been more generally experienced than any other single trouble, and, as those are expensive units, the cost of replacement has been high. The usual form of failure is a crack in casting between the valve ports, usually between the two exhausts, where a large amount of heat is present, and where water circulation is least likely to be positive and copious. This condition may be aggravated by piping systems which do not provide for water circulation at low speed, or after stopping a hot engine, by operating with low water, or by the use of excessive amounts of alcohol or other anti-freeze compounds, and the use of manifold exhaust pipes and high back pressure in mufflers.

TABLE 5.—WEAR CRANKPINS

A—.007 to .009 in. out of round in 95,000 miles.
B—.004 to .009 in. wear in 100,000 miles.
.002 to .003 in. out of round in 100,000 miles.
C—.002 to .004 in. wear in 60,000 miles.

Progress has been made in the training of personnel, eliminating air and steam pockets, changing the material of the head and thorough annealing the castings, increasing water pump capacity, and securing free flow of water at all times, including provision for thermosyphon action. Lack of sufficient pump capacity to maintain water circulation at idling speeds appears to have been responsible for a certain proportion of cylinder head failures.

Excessive wearing away of valve seats, due to softness of the material, or to continued reseating eventually causes scrapping of the head. Some progress has been made with the insertion of replacement seats though this has not yet been carried far enough to give conclusive results.

Valves

Occasional cases of sticky valves have been reported. In one case this seems to have been due to the particular brand of commercial gasoline used, as the trouble ceased upon changing to another brand. Others have found sticking to be caused by too long valve guides, with excessive space for the formation of carbon. The remedy suggested for this is to use hard bronze guides, cut off nearly flush with the wall of the port, and having a minimum of clearance on the valve stem. Other valve troubles have been due to improper adjustment of the tappet clearances or inaccurate seating. Twenty to 25,000 miles is considered good average service between valve grindings.

Minor but annoying difficulties have been experienced with valve stem caps and tappet adjustments, indicating that improvements may be looked forward to along these lines.

Cooling System

(See also: cylinder heads, cylinder sleeves, and lubrication).

Strong sentiment is shown toward the roof type of radiator, and where possible, elimination of air circulating fans. Means for cutting out portions of the radiating surface are considered desirable, and all outside water passages should be made self-draining into a reserve water tank inside of the car. Thermostatically controlled by-pass connections are looked upon with favor, provided that a sufficient mass of water is kept in circulation to prevent too rapid changes in temperature. Control valves should, in general, have drilled gates or discs to permit of drainage and the equalization of temperatures.

Provision for keeping the engine and circulating water warm during layover periods, either by direct interconnection with the car heating system, or through the use of special heating coils, is desirable, as a means of preventing freezing and improving lubrication conditions. Such connections should be arranged so that no damage can be caused by carelessness or neglect of the operator.

Fuel System

General dissatisfaction is shown with vacuum type systems, due both to the difficulty of keeping lines tight and to insufficiently rugged construction of float and valve mechanisms. Pressure feed systems, though reliable, involve a fire risk in the case of accident. Efforts are, therefore, being made to find satisfactory substitutes for these, and encouraging reports are made on vane and gear type pumps driven by small electric motors, and on special types of pumps driven from the main engine. One road is insuring reliability by adding an entirely distinct system for emergency or stand-by service, using groups of electromagnetically operated syphon pumps.

Fine mesh fuel strainers of ample capacity are strongly recommended, though some trouble has been experienced with the clogging of very fine gauze and of chamois strainers. Dirt or water in gasoline or fuel oil lines are responsible for a considerable proportion of delays, and it is apparent that too much care cannot be exercised in the handling and storage of fuel, to eliminate all foreign substances.

The chief mechanical difference between the Diesel and other engines lies in the fuel injection pumps, and questions regarding the life reliability and maintenance costs of either air or solid injection systems in railway service have often been raised. The following information regarding injection pumps is, therefore, of particular interest. Main fuel pumps fail, due to scoring of the plungers, wear, and very occasionally, seizing. The average mileage of a fuel pump is now 50,000 miles before any attention is required. The bushings may then need renewing. About six cases of trouble due to lack of adjustment of ball check and relief valves have been reported, but these were all due to ignorance and should not occur again.

Ignition

With the exception of one railway which reports excessive trouble with magnetos, ignition complaints are limited to minor spark plug troubles.

Many failures, of more or less serious nature, are due to frequent changing of crews, and insufficient time given to the instruction of new men. While the changing of crews presumably cannot be avoided, the short sightedness and false economy of entrusting expensive equipment to men who have received insufficient instruction, and who have not demonstrated a satisfactory knowledge of their equipment, and the proper method of handling it under all conditions, is becoming recognized, and on several railways the instruction of operators and maintenance forces has been made a major part of the rail car programme.

Summary

The information above submitted led the sub-committee to the belief that serious failures of important engine parts have been reduced to a point where they cause no further serious concern, but indicate that some attention should be paid to the details of auxiliary apparatus, and to the establishing of improved shop practices which will serve to detect and remedy other incipient causes of trouble before they result in failures. By so doing, the availability of equipment and its reliability in service will be maintained at a maximum.

The sub-committee feels that as the initial problems of rail car operation have to a large extent been satisfactorily met, the problem of securing rail car service at a minimum of operating cost is one to which a larger proportion of attention can now be given, and it is recommended that studies during the coming year be devoted largely to an investigation of the relative advantages of different fuels, the probable development in the availability of such fuels in the future, and the technique of burning the fuel satisfactorily in internal combustion engines.

Cranes to Handle Loaded Freight Cars

Two freight car loading cranes of unusual design—the first to be designed for loading and unloading entire freigh cars in and out of ships—are now being built for the Overseas Railway Company, by the Shaw Crane Putnam Machine Company of Muskegon, Mich. The cranes will be installed on piers at New Orleans and Havana, Cuba

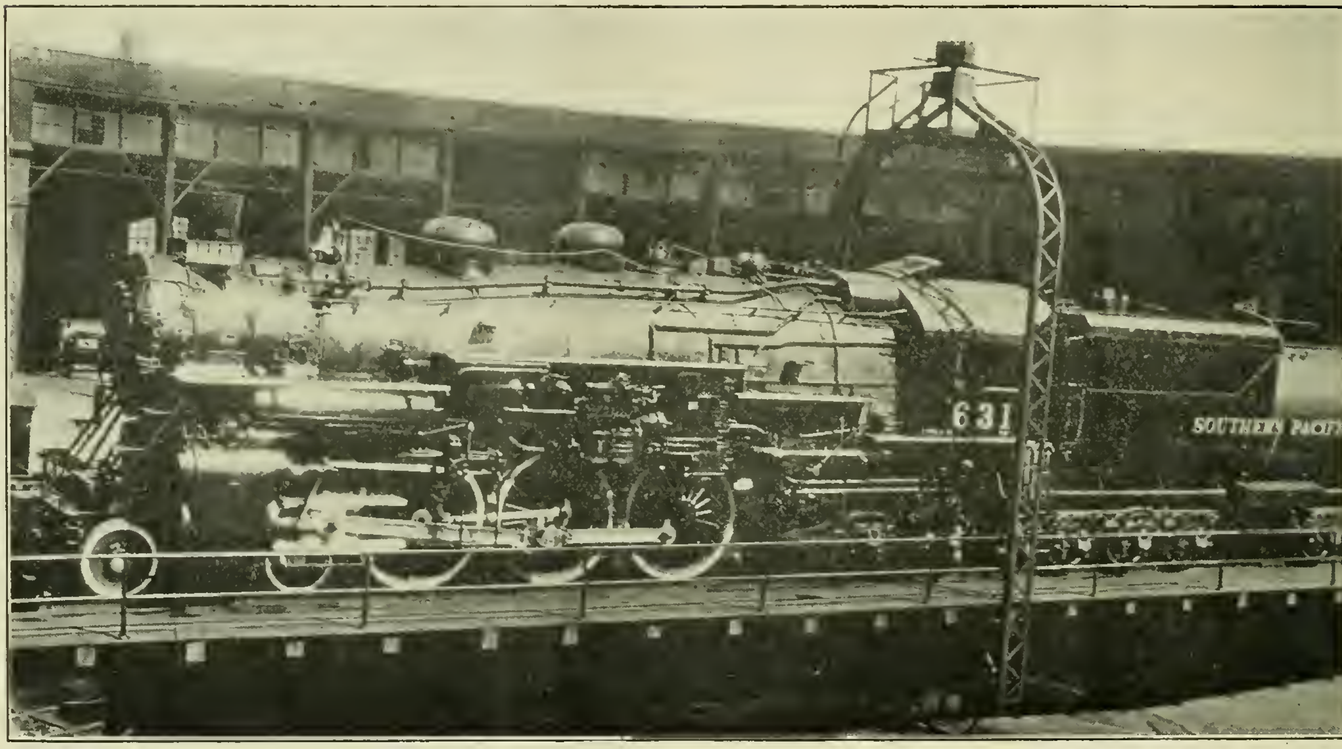
A special ship with a handling capacity of about 95 refrigerator cars is now being built in England, and in this the cars will be transported between the two points This ship will have three enclosed decks each equipped with four storage tracks and a central hatchway through which the cars will be lifted or lowered. For loading the ship, one car at a time will be run upon a special cradle on the pier. The cradle will then be picked up by the crane, car and all, and lowered into the ship. Once in the ship, the car will be run off on a storage track. This process will continue until each of the three decks is loaded to capacity, when the ship will proceed on its trip to the other terminal where the process will be reversed for the removal of the cars.

A New Turntable on the Southern Pacific Railroad

Use of Timken Anti-Friction Bearings and Other New Features are Used in the Design

The Southern Pacific Railroad has recently installed a round-house turn table at Houston, Texas, which is completely equipped with anti-friction bearings and possesses several other features of considerable interest. The table, which was built by the American Bridge Company, is of the continuous girder type, having an overall length of 100 feet, and width of 17 feet. The load capacity is 375 tons. The table is driven by two 15 h.p. adjustable constant speed wound rotor induction motors, one at each end, which give it a maximum end speed of 180 feet per minute.

The table proper consists of two continuous girders trucks, two of which also carry the driving motors and mechanisms. Provision has been made for vertical adjustment of the table, both at the center and at the end truck connections. As a result of this arrangement it is possible both to compensate for discrepancies in the relative heights of the center and pit rail foundations, and to adjust the center and end dead load reactions to the best advantage. The pit rail is a 130 lb. Pennsylvania Railroad standard rail, mounted on steel bearing plates spaced 2½ feet between centers. It is fastened to the plates by patented adjustable washers which lock it permanently in



Locomotive on Timken Bearing Equipped Turntable at Houston, Texas. Table Can Be Turned Manually by 12 Men

which are given great lateral rigidity by bracing at both the top and bottom which extends their whole length. The girders are connected by heavy cross frames that extend for their full depth, being joined to the upper and lower lateral bracing at each panel point. This construction imparts a rigidity to the whole structure that is particularly advantageous when it becomes necessary for any reason to drive the table from one end only. It also assures perfect vertical alignment between the table rails and the approach rails, by increasing the horizontal strength and rigidity of the structure at the center. The frame work is covered by a deck of ties and heavy planking extending for some distance at the side of the girders, upon which the table rails are laid.

The table is supported at the center by two heavy cross girders which bear directly upon an anti-friction cone-roller bearing center pedestal of improved design and construction. The ends are supported by four two-wheel place against the dislocating action of any forces which may be applied to it.

One of the interesting features of the table is the construction of the center. Essentially it consists of two heavy circular castings, one forming the base, and the other the upper bearing housing, which is also the support for the table proper. The base has an overall diameter of 4 feet 6½ inches, and is anchored in place by angle clips that extend into the concrete of the foundation, and prevent any tendency for it to slip or twist out of alignment. The top bearing housing is made self-aligning by a heavy rounded boss that carries the table support. Alignment during turning is assured by a thick cylindrical stud cast integrally with the base which projects into a corresponding well in the upper housing, the former being fitted with a bronze ring which takes any side wear between the moving and stationary parts. The center reaction of the table and its load, which may amount to a maximum of 580,000 lbs., is carried by the tapered roller thrust bearing with which the center is equipped. The lower race of the bearing is supported by a circular platform cast integrally with the base, and the upper race is pressed into a shoulder machined in the upper housing. The outer closure of the center is formed by six curved castings which are bolted to the upper housing and to each other, and which can easily be removed to permit inspection of the bearing. Oil plugs are provided in the base so that used oil can be quickly drained off.

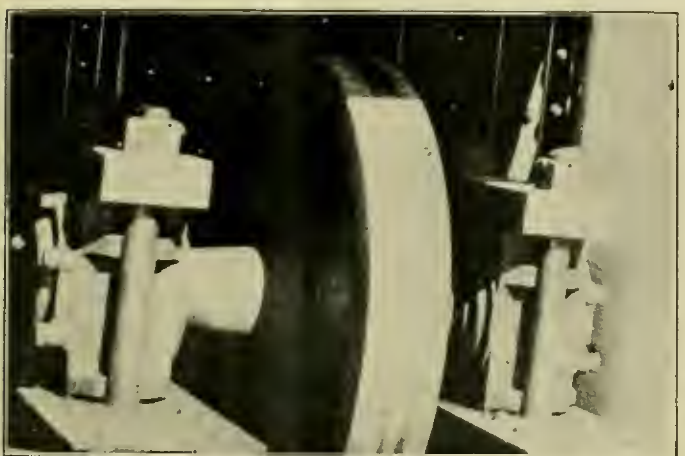
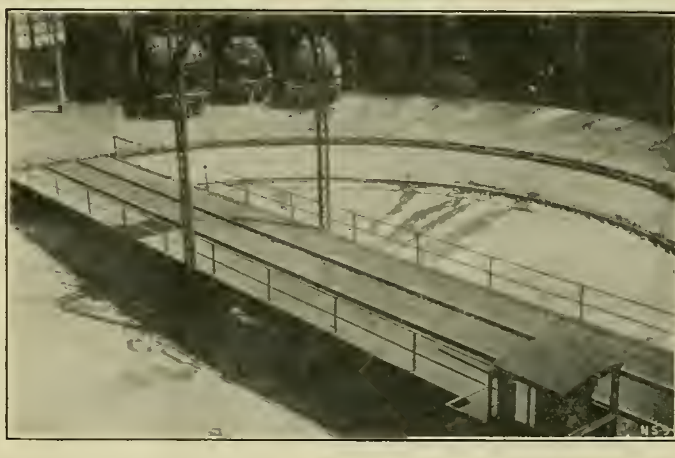


Fig. 2—Close-Up of One of the Truck Wheels Showing the Method of Mounting the Roller Bearings

The construction of the trucks and the operating mechanisms which they support also incorporates some novel features. Each truck consists of two units, fastened to the main girders in such a way as to permit a certain amount of rotation around the point of connection. Each truck unit is provided with two standard 36 inch Carnegie rolled steel wheels, the flanges of which have been removed. The method of mounting is such that the truck frame is suspended from the axles, the whole weight of the truck, and its proportion of the table load, being taken by the Timken bearings with which the truck wheel axles are equipped. A good idea of the method of mounting can be obtained from Fig. 2. The load per truck range from 165,000 lbs. static load, occasioned when an engine comes on the table to 125,000 lb. maximum turning load.

The driving mechanism at each end, consisting of the 15 h.p. back geared induction motor, and the necessary intermediate gears, is mounted on a cantilever extension on the off truck frame. This mounting has the effect of increasing the dead load reaction on each of the driven wheels to a point where there is no danger of slipping the wheels when the unloaded table is rapidly accelerated and eliminates the necessity for sanding the pit rail, even in wet weather. Power for the motors is brought to the table through a revolving contact located at the apex of a lattice work arch erected at the center of the table. The control for both motors is centralized in the operator's house at one end of the table, the electrical control being supplemented by a manually operated brake which is applied to a drum on the motor counter shaft. Thus the table can be stopped when the motors are out of service for any reason. In case of failure of power, or if it is necessary for any cause to turn the whole table manually, provision has been made for disconnecting the driving mechanism from the wheels. The main drive pinion is mounted on a sleeve that is normally held in place by a set screw. Loosening of the screw permits sliding the pinion out of mesh with the main driving gear. Thus the table can be turned manually without working against the inertia of the motor armatures and back gears.

Since the installation of the table several interesting facts have developed concerning its operation. In the first place the liberal use of Timken bearings reduced the initial horse power requirements per motor from 25 to 15 h.p. On the basis of the number of table movements made per day, the saving in power consumption alone has been enough to pay the increase in investment represented by the bearings. The reduction in friction thus obtained coupled with the provision for disconnecting the driving mechanism just described have been directly responsible for the elimination of another expense, that for the initial cost and upkeep of emergency turning equipment, such as compressed air or gasoline motors. It has been found that six men can turn the table by hand when it is unloaded and that 12 men can turn it manually when it is loaded with a heavy locomotive.



General View of the Turntable Unloaded

Condition of Motive Power

Locomotives in need of repair on the Class I railroads of this country on December 1 totaled 8,340, or 14.2 per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was a decrease of 449, compared with the number in need of repair on November 15, at which time there were 8,789, or 14.9 per cent.

Locomotives in need of classified repairs on December 1 totaled 4,413, or 7.5 per cent, a decrease of 348, compared with November 15, while 3,927, or 6.7 per cent, were in need of running repairs, a decrease of 101, compared with November 15.

Class I railroads on December 1 had 5,560 serviceable locomotives in storage, compared with 5,234 on November 15.

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Inventor of the First Locomotive

Despite the growth of education and the general distribution of encyclopaedias and books dealing with the steam locomotive, it appears impossible to kill the fallacy that "Stephenson invented the locomotive." Neither Stephenson nor his friends ever claimed that he was the "inventor of the locomotive," and there are standard works on locomotive history giving the true facts. Cugnot's locomotive was running on the streets of Paris in 1769.

Murdock's model of a road locomotive is said to have been constructed about 1784, and measures 19 inches long, 7 inches wide, and 14 inches high. A replica is in the South Kensington Museum. Murdock's model was stated to have been made at Redruth. In the neighboring Cornish mining town of Camborne, Richard Trevithick is credited with producing a parlor-model locomotive in 1796 and on Christmas Eve, 1801, had a steam locomotive running in the streets of Camborne, to the great consternation and fright of the inhabitants.

In August, 1802, Richard Trevithick built the first railway locomotive at Coalbrookdale, while Trevithick's second railway locomotive performed a successful journey on the Pen-y-Darren Tramroad in South Wales in February, 1804, and as the result of a wager won its backer a bet of 500 guineas.

Blenkinsopp (or Murray), Chapman, Brunton, Hackworth (or Hedley) and Stewart all constructed more or less successful railway locomotives before George Stephenson's first locomotive, *Blucher*, was tried on the Killingworth Colliery Railway on July 25, 1814.

Great Gains Made in Safety Campaigns

A reduction of approximately 17 per cent was shown in the accident rate of all railway employes on duty during the first seven months of 1928, as compared with the corresponding period last year, according to the Bureau of Statistics of the Interstate Commerce Commission. An improvement was shown by every department connected with railroad operation.

This is the direct result of the safety campaigns which the railroads have been persistently conducting on their individual lines during the last few years.

The measuring rod which the Commission applies in determining the relative safety is the figure showing "casualties per million man-hours." This covers the actual number of hours worked by all employes of the steam railroads during the period under consideration.

The Commission reports that casualties per million man-hours, covering both killed and injured employes on duty, in the first seven months of 1928 stood at 17.07, a reduction of 3.58 or 17.3 per cent as compared with the first seven months of 1927.

The casualties per million locomotive-miles (killed and injured), which covers both employes and passengers, amounted to 24.48 for the first seven months this year, a reduction of 3.33 or 11.9 per cent as compared with the same period of 1927.

Fatalities resulting from highway grade crossing accidents in July this year totaled 148 compared with 227 in July last year, or a reduction of 79, according to reports filed by the carriers with the American Railway Association. Reports also showed 434 persons injured in such accidents in July, which was a decrease of 77 compared with the same month the preceding year.

Highway grade crossing accidents in July, 1928, totaled 374 compared with 430 for the same month one year ago, or a decrease of 56.

For the seven month period, 1,245 fatalities were reported due to highway grade crossing accidents compared with 1,288 for the corresponding period last year, or a decrease of 43, although there was an increase of eighteen in the number of such accidents. Persons injured in accidents at highway grade crossings for the first seven months this year totaled 3,368 compared with 3,412 in the same period in 1927.

Federal Regulation of Buses

While no legislation has been enacted governing the regulation of motor buses, some progress has been made in the direction. The Interstate Commerce Commission has definitely and clearly endorsed legislation in substance and nearly all organized representatives of motor passenger carriers as well as the representatives of competing rail carriers both steam and electric, also approve such legislation. Such opposition as makes itself heard comes mainly from those whose interest lies in the direction of the greatest possible production and sale of motor vehicles.

There is some opposition from among those operators engaged in freight carriage, who believe that if regulation shall now be provided by law for passenger carriers it will shortly be extended to them. There are also a few independent passenger carriers who, for reasons not quite clear, wish to differ from those who are organized. Under these circumstances the enactment of Federal legislation providing at least for the regulation of interstate passenger motor carriers seems probable in the not distant future.

Economics, and Not Politics, Should Govern

The downward tendency of the railroad rate level, if not checked, "cannot fail to lead to the same conditions which confronted the railroads in 1913, and even more seriously in 1917, when they were taken over by the Government," according to Daniel Willard, President of the Baltimore & Ohio Railroad Company, in a recent address before the Indianapolis Traffic Club.

"The railroads are not asking for anything except that they be treated as contemplated in the Transportation Act," Mr. Willard told the shippers. "If that is done they will continue able to furnish service adequate and suitable to your requirements."

Pointing out that in no year since the passage of the Transportation Act in 1920 have the railroads as a whole earned the return of 5¾ per cent "designated as fair by the Commission," Mr. Willard issued a warning against political solutions being sought for economical questions. Referring to the attempts to repeal by legislation the Pullman surcharge, he said:

"It is estimated that the cancellation of the surcharge would reduce the revenue of the railroads about $40,000,-000 per annum. I personally believe that the charge is a reasonable one and fairly justified by the more expensive character of the service which it covers, and the Interstate Commerce Commission has also expressed similar views.

"The Hoch-Smith Resolution is another instance of political action concerning an economic problem. Under the influence of the last-mentioned Resolution, the carriers' revenues have already been substantially reduced, although they were not then and are not now earning as much as the Interstate Commerce Commission itself, acting under instructions contained in the Transportation Act, has said would be fair and in the public interest.

"To provide for necessary facilities, to continue the program of separating grade crossings, etc., the railroads should raise and spend upward of $750,000,000 new capital stock each year, in order that they may continue to furnish the kind of service you desire. The railroads are not asking, however, for any change in the Transportation Act to enable them to carry this burden; they only ask, and this they do ask, that they be treated as it was clearly intended they should be when the Transportation Act was passed—that is to say, be permitted to charge such rates as will enable them to earn each year as nearly as may be a fair return on the value of their property devoted to the public use."

Nationalization of Railways a Costly Luxury

"The deficit of the Belgian State Railways during 1925 amounted to approximately 78 million francs, as compared with the budget estimate of 6 millions, and this in spite of the marked efficiency of the railway administration," according to C. E. R. Sherrington, Secretary, Railway Research Service, London School of Economics and Political Science, University of London. These figures were quoted by Mr. Sherrington as an example of the drain which State-owned railways make on government expenditures.

In an article last week in *Railroad Data*, Mr. Sherrington pointed out that Europe has found that the State-owned railways were leaning heavily on the national budget; and that the financial stability of the individual nations was largely bound up with the elimination of these railway deficits. The result is that, in one form or another, the various governments have been adopting policies designed to make the steam carriers self-supporting. Continuing his discussion of the railway situation in Belgium, Mr. Sherrington says:

"The low level of passenger fares and freight rates, however, due to political influence is a disadvantage which no management, however efficient, can overcome." But even under semi-private management, Mr. Sherrington adds, "the overstaffing of the railways, also due to political pressure, is already in process of being solved.

"As in the case of France, the State does not surrender its actual ownership of the railway property; it merely leases the property to an operating company. The disadvantage of direct State operation is more striking in this case than in any other as the efficiency of the management itself has never been questioned."

Turning now to Austria, Mr. Sherrington first describes the demoralized condition of the Austrian State Railways as the result of the war. He continues:

"The depreciation of the Austrian kroner was intimately connected with the increasing deficits resulting from State operation of the railway, and it became essential to divorce its finances from that of the national budget. This was finally achieved toward the end of 1923, from which time consistent progress has resulted. The operating deficit for the last quarter of 1923 amounted to no less than 259 million kroner. At the end of 1924 this had been reduced to only 12 million kroner covering the whole year.

"A main source of economy, as in the other cases previously mentioned, was the reduction in staff, although such reductions must necessarily increase the sums required for pensions, at least for the first few years. Between October, 1922, and December, 1924, no less than 45,000 employes were dismissed, a reduction of 33 per cent. The majority of the other economies effected were mainly of an operating nature. It is specially significant that these betterments could only be carried out after the new regime had come into power, bringing with it a thorough reorganization. This resulted in modernization and greater commercial progress, which had been impossible when dependence had to be placed on the permission of the Ministry of Finance.

"This freedom, so necessary to all industrial enterprises, proved of especial benefit in connection with the placing of important contracts. It would be no exaggeration to say that the financial stability of Austria was largely bound up with the elimination of her railway deficits and apparently she found it impossible to effect this change without the separation of railway finance from that of the national budget."

The Railways' Part in Mail Service

The steam railways are the most important post roads in America. Almost all United States mail, except local mail, is carried in some part toward its destination on a railroad.

The railroads now have a complete system for handling and distributing the mails, but its organization was a gradual development.

At first, mail for all post offices on a route was placed in one pouch and each postmaster sorted the entire contents to obtain the portion directed to his office. Then direct pouches were exchanged between offices of importance. Their number increased rapidly as the country and railways developed. The enormous number of direct pouches, most of them only partly filled, required a new system to facilitate handling.

As a result, route agents were assigned to railway mail trains and from these was evolved the present system of railway mail clerks. The route agent sorted mail in transit and made up the pouches for each office on his line. He carried to the next distributing office all mail for points beyond his run.

To eliminate the resulting delay at division points, distributing office clerks familiar with the general distribution of the mails were detailed to travel on mail trains. Their duty was to make proper separation and distribution for all connecting lines. The mails were thus ready for immediate dispatch upon arrival at the route terminal.

The first railway post office is variously claimed to have been operated in Missouri on the Hannibal & St. Joe Railroad, in 1858; between Chicago, Illinois, and Clinton, Iowa, in 1864; and out of Council Bluffs, Iowa, in 1867.

After the idea of the postal car was introduced, however, its use spread rapidly. From 1864 to 1917 the length of lines on which railway post office service was in operation increased from 22,000 to 234,000 miles, and the annual travel of railway mail employes from 23,000,000 to 502,000,000 miles. The number of employes themselves increased from 572 to nearly 18,000.

Terminal railway post offices under supervision of the railway mail service have been established for handling parcel post and ordinary mail. Located at important commercial and rail centers, in railroad stations where possible or in convenient adjacent buildings, these offices eliminate delay. Without the terminal office, the mail would be lying still or being distributed in the costly train space, while now it is separated for direct dispatch to post office or railway post office lines without loss of time.

Here is handled the great volume of parcel post and advertising matter which would congest cars and impair the distribution of mails of higher classification. Then it can be forwarded in storage cars at maximum speed. This system has made parcel post possible.

Mail at terminals is also massed and redistributed into direct sacks for destination office or is directed in pouches to the railway post office line serving a particular section.

Since 1916 mail in postal cars has been handled on a space basis instead of by weight as formerly. Tests are conducted once every two years to determine the amount of mail that can be handled in a 3-foot unit of space. Space is then determined on an actual count of mail handled.

The mails are carried on 4,713 railway post office trains, and 13,838 closed pouch trains, over a total of 228,992 miles of railroad, at a cost during the year ending June 30, 1927, to the department of $106,919,903. There are in use at this time 860 full railway post office cars and 4,023 apartment mail cars.

Equipment Installed in First 11 Months

Class I railroads in the first eleven months this year installed 54,382 freight cars, according to the American Railway Association. Compared with the corresponding period last year, this was a reduction of 17,846 in the number of freight cars installed.

Freight cars on order on December 1 this year totaled 14,375, compared with 9,850 on the same date last year.

In the month of November, the railroads installed 3,760 freight cars, compared with 5,864 in November last year.

Locomotives placed in service by the Class I railroads during the first eleven months in 1928 totaled 1,258, a decrease of 562 under last year. Locomotives installed in November numbered 68, compared with 149 placed in service in November, 1927.

Locomotives on order on December 1, 1928, totaled 123, compared with 69 on the same date in 1927.

These figures as to freight cars and locomotives include new and leased equipment.

Freight Cars In Need of Repair

Class I railroads in December 1 had 139,053 freight cars in need of repair, or 6.2 per cent of the number on line, according to reports just filed by the carriers with the Car Service Division of the American Railway Association.

This was an increase of 720 cars over the number reported on November 15, at which time there were 138,333, or 6.2 per cent.

Freight cars in need of heavy repairs on December 1 totaled 100,756, or 4.5 per cent, a decrease of 1,637, compared with November 15, while freight cars in need of light repairs totaled 38,297, or 1.7 per cent, an increase of 2,357, compared with November 15.

The Year 1928 in the Electric Railway Field

By W. D. Bearce, Railway Engineering Department, General Electric Co.

The most important steam railroad electrification initiated during the year 1928 was the Cleveland Union Terminals project. Plans for this development have been under way for several years; and the new terminal building, 54 stories in height, has been completed with the exception of the lower portion which is to be occupied by the railroad station. The electrification involves 17 route miles, and will employ 3000-volt direct current with overhead catenary supply.

There are now under construction at the Erie Works of the General Electric Company twenty-five 204-ton passenger locomotives, rated at approximately 3000 horsepower each, which will be required for handling passenger trains of the New York Central and other roads in and out of this terminal. The design of this locomotive includes two three-axle driving trucks, with six twin geared motors and a two axle guiding truck at each end of the unit. These locomotives will be capable of handling 1275-ton trains over the electric zone at an unusually high schedule speed.

Two substations will be used for direct current power supply, one containing three 3000-kilowatt synchronous motor-generator sets and the other containing two similar sets. Power will be purchased from the local power company. While the work being done at present is strictly a terminal electrification, the system selected will permit further extensions on the main line of the New York Central at the same trolley voltage.

An important decision was made recently regarding the selection of a system by the Delaware, Lackawana and Western Railway. This company has announced that the 3000-volt system will be used for the electrification of the Hoboken Terminal and Suburban zone, for which equipment will be in order during the coming year. The selection of this system will permit extension of the electric zone over the main line to Scranton without change of trolley voltage.

Another notable electrification has been completed during the year by the so-called "Narrow Gauge"—the Boston, Revere Beach and Lynn Railroad. This road has been an important passenger line for many years. It has been electrified to improve equipment, make faster schedules and thus further increase the possible business. The steam locomotives have been replaced by electric motor cars, operated in trains of from two to eight cars each. The existing passenger coaches have been equipped with motor and control equipment, new lighting and heating, and are modern in every respect. A total of 60 cars have been equipped for the present service. Three substations have been provided, one at Orient Heights near Boston, the second at Lynn, and the third a portable station. One of these substations will be completely automatic. They will be supplied from the local power systems at Lynn and Boston. As a part of the improvement, turnstiles have been installed at the various stations for fare collection. The overhead construction is of the catenary type for 600-volt direct current, using steel bridges throughout.

Delivery has been made during the year of additional passenger locomotives to the Paulista Railway in Brazil.

Baldwin-Westinghouse Electric Locomotive on the Great Northern Railway bringing the total number of the heavy 150-ton type up to five units, and the total number of all General Electric locomotives to 26 units.

Two 260-ton locomotives constructed similarly to those originally installed last year have been placed in service by the Great Northern Railway on the electric zone through the Cascades. Operation through the new 7¾ mile Cascade tunnel began December 28, 1928.

Two 150-ton, 3000-volt direct-current locomotives are under construction for the Mexican Railway to care for additional motive power requirements for the extended electric zone.

Both locomotives and car equipment have also been installed on the Pennsylvania Railroad. This equipment includes motors and control for four 200-ton locomotives built by the railroad company for operation on the New York Terminal, and thirty single-phase motor car equipments for the new Wilmington and West Chester divisions.

Other equipment for this electrification includes a number of type JRA-28 air-break high-speed circuit breakers for use on 12,000-volt, 1500-ampere, single-phase feeders. This is the first commercial alternating-current air-break circuit breaker to be designed for so high a voltage. The breaker is capable of opening a short circuit on 25 cycles on one-half cycle, and has a rated rupturing capacity of over 30,000 root-mean-square amperes. Because of the high speed of circuit interruption, this device is valuable in the reduction of inductive interference with communication and signal circuits.

Oil-Electric Locomotives

A total of 13 oil-electric locomotives have either been installed or placed under construction during the past year. These include a number of industrial installations such as the Donner Steel Company which is using four 60-ton units each equipped with a 300-horsepower Ingersoll-Rand oil engine, and the American Rolling Mills Company which has installed, during the year, a 100-ton locomotive equipped with two 300-horsepower Ingersoll-Rand engines and three 74-ton locomotives each equipped with one 300-horsepower engine. The Reading Company has added a 60-ton, 300-horsepower locomotive, the Erie Railroad a similar unit, and the Hoboken Terminal Railroad both a 74-ton, 300-horsepower locomotive and a 110-ton, 600-horsepower unit. The Illinois Central Railroad has placed in service a 100-ton, 600 horsepower locomotive in its switching yards in Chicago.

Gas-Electric Motor Cars

The thorough appreciation of the advantages of the gas-electric motor car for branch line steam road service is indicated by a total of 117 cars placed in service during the year. Some of the larger installations have been made by the Pennsylvania Railroad, 14 cars; the Chicago and Northwestern, 28 cars; the Frisco System, 7 cars; the Chicago, Rock Island and Pacific, 14 cars; the Missouri Pacific, 4 cars; and the Chicago, Burlington and Quincy Railroad, 29 cars. These cars vary somewhat in weight and power, ranging from 200 to 800 horsepower, with one two or three power plants.

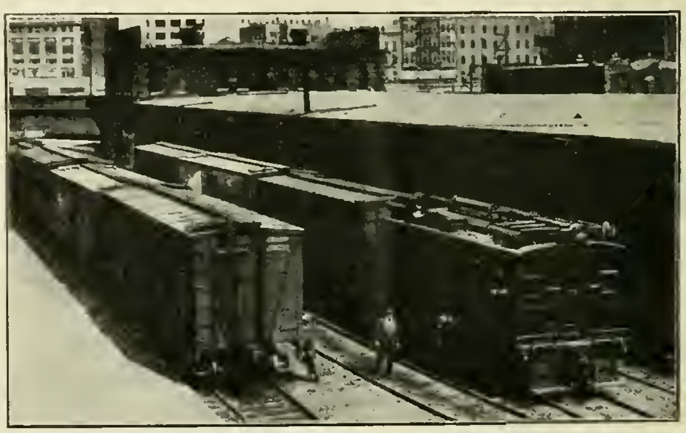
The self-propelled equipment of the Chicago, Rock Island and Pacific Railway, popularly known as the "Rock Island," and the Union Pacific Railroad is especially notable on account of the successful use of distillate fuel in place of the usual gasoline, and because of the unusually high power of some of the cars now in service. Several Rock Island units used in branch line work carry two 400-horsepower engines. This permits the car to be used for either passenger or light freight work, eliminating steam entirely from some of the branch lines.

An interesting demonstration was made on October 2 by the Chicago, Burlington and Quincy Railroad with a gas-electric car train. The equipment used consisted of a dual power plant, 270-horsepower car used at one end of the train, and a triple power plant, 405-horsepower demonstrator car equipped by the Mack Company, with two standard day coaches between them—making a total trainweight of about 230 tons. Temporary electrical connections between the two motor cars permitted operation of the train by a single engineman in the cab of the 72-ton triple power plant car on the outbound trip. On the return trip, without any change in arrangement, the train was operated from the dual power plant car at the opposite end of the train, and in reverse direction. During the 21-mile trip outbound stops were made at the rate of one per mile, and on the return trip the train was run express. About 60 railroad men and others interested in automotive equipment were present at the demonstration.

Radio Communication

Radio equipment for communication between the front and rear ends of long freight trains, previously tried out by the New York Central, has now been installed by the Baltimore and Ohio Railroad for demonstration on that system.

A unique application of radio equipment to locomotive operation is being tried out by the American Rolling Mills Company at Ashland, Kentucky. The equipment being used is similar to that used on main line freight lines, but in this case one unit is installed in the yard dispatcher's office and the other on the locomotive, working in the yard around the plant. Two-way communication is being provided, enabling the dispatcher to issue an order and the locomotive crew to reply.



Oil-Electric Locomotive in Service on the Chicago & Northwestern Railway

The Effect of Design of Front Ends, Grates, Ash-Pans and Coal Gates, on Locomotive Operation

A Paper Presented to the Traveling Engineers' Association by Frank P. Roesch

It must be distinctly understood that no criticism is intended in anything that follows, it being recognized that in the major problem of designing a locomotive there are details of possibly more importance. Furthermore, that the designing engineer is not in position to recommend untried ideas, but must of necessity confine himself to designs that have stood the test of service and are in themselves recognized as fundamentally sound practice. In fact, any experiments or departures from generally accepted practice must be made by the railroads themselves, as it is only in actual operation that new ideas can be worked out to a conclusion, successful or otherwise.

The suggestions following are based on extensive reading, some observation and some experience: if they contain ever the germ of an idea that may help improve the locomotive operation on American railroads, well and good; if not, they may at least serve as a basis for discussion, and so bring out something that may be worth while.

Front Ends

This heading is supposed to apply primarily to such parts of the locomotive front end as are generally termed the draft appliances, viz., the nozzle, stack, petticoat pipe, diaphragm plates, etc., and their relation to one another.

Of course, we all understand that the only function of the so-called draft appliances is to create the greatest front end vacuum with the least cylinder back pressure. We also understand that the only purpose of the front end vacuum is to create a corresponding vacuum—allowing for tube friction, etc.—in the fire-box. Therefore, it must follow that anything that interferes with the proper transfer of the front end draft or vacuum can be considered as more or less detrimental.

We know that during the process of combustion a certain amount of gas is liberated or produced in the fire-box per pound of coal burned per hour. We also know that this gas must pass through the tubes, the front end, and out of the stack, and that where the area of discharge is limited, or the gas currents materially baffled, the velocity must be increased to correspond, and as velocity is usually obtained by reducing the nozzle, it is not difficult to trace the effect of design to cylinder back pressure, and from there to locomotive operation. It might be well in this connection to review briefly the development of the locomotive front end draft appliances as in general use today.

In the first locomotives, natural or stack draft was depended upon, and therefore, in the earlier locomotives, a very long stack was employed. Later on a fan at the base of the stack was tried, but soon discarded as impracticable. This was followed by a steam jet similar to our present blower, and was used until George Stephenson hit on the idea of utilizing the energy of the exhaust steam to create draft.

Possibly few appreciate the value of this discovery or idea, but if we stop to think we can see that of all devices tried, even to the present day, it is the most practical, economical and fool-proof. Through the use of the exhaust jet we have an almost automatic operation, in that as the demand for steam on the boiler is increased, by the use of more steam in the cylinders, the amount of steam exhausted is correspondingly increased, which in turn increases the front end vacuum and so completes the cycle.

In the first locomotives using the cylinder exhaust jet to produce fire-box draft, the long stack was continued, the diameter of the stack being practically equal to the cylinder diameter, and this ratio obtained up to the time the diamond stack, so-called, was discontinued, and designers returned to the original straight stack. In these earlier locomotives the exhaust nozzle stand was fairly high, coming up to about the center line of the boiler.

While this design gave a free and full draft, trouble was soon encountered due to the excessive discharge of cinders from the stack. Of course, the logical remedy was the application of netting. It was also decided that the best place for the netting was in the top of the stack, but as even in those days it was appreciated that any restriction to the free flow of the exhausted gases interferred with or affected the draft adversely, it followed that in applying netting it was necessary to so design the stack that the total area of the netting opening must be at least equal to or preferably greater than the stack area. And this gave birth to the so-called balloon stack.

We wish to pause here to remark that while in the beginning we referred to English and Continental practice, we are now with the advent of the balloon stack referring strictly to American development, as the American engineers found many more difficult and vexing problems confronting them than did their English and Continental brothers, due to difference in fuel, operating conditions, etc.

In the earlier locomotives the high nozzle stand was retained, but engineers, noting that the height affected the cylinder back pressure, began to cut it down. Here again they ran into trouble, however, as with the lower stand the spread of the jet caused the outer part to impinge against or strike the smoke-arch, and it was therefore necessary to develop some means to overcome this, and thus the so-called petticoat pipe was born.

History fails to record the name of the man who invented or designed it. The first mention we find appears in Zerah Colburns' book, "The Locomotive Engine," Boston, 1851, and in an illustration of the stack and front end of a B. & O. anthracite coal-burning locomotive in the

Feb. 8, 1861, issue of "The Engineer," the official organ of the London Institute, from which we quote:

"The illustration represents an anthracite coal-burning passenger locomotive, as built for and at the shops of the Philadelphia & Reading Railway, U. S. A boiler of the same kind is now being made at the Ivry workshops of the Paris & Orleans Railway, with the view of the partial, if not general, adoption of American anthracite on that line. The engine shown has 15 in. cylinders, 20 in. stroke, four coupled driving wheels, 5 ft. 6 in. in diameter. The weight of the engine in running order is 25.2 tons, or 56,450 pounds. The fire-box is 7 ft. long inside (on the fire-bars), and 3 ft. 6 in. wide. Its sloping roof is semi-elliptic in cross section, the ordinary water level being within 4 inches of the top of the cylindrical portion of the boiler. The fire-box is made throughout of 5/16 in. iron, with the exception of the tube plate, also of iron, which is ⅜ in. thick. The inside fire-box plates, before being tapped for stay bolts, are indented at points answering to the positions which those bolts are intended to occupy, the indentations being circular and say ⅜ in. deep, and producing a corresponding projection on the opposite side. This indentation is alleged to prevent the cracking, to which, under the action of anthracite coal, the plates are otherwise liable at the stay bolts. The fire-bars, 14 in number, are hollow, lap-welded iron tubes, 2 in. outside diameter, and ¼ in. thick, and are screwed in at each end, holes (afterwards closed by brass plugs) being left in the outer fire-box plates, opposite the ends of the water tubes, for convenience of cleaning. The fire-bars, 7 ft. long, are supported by a cross bar at the middle of their length. They are arranged with respect to each other, as shown in the cross section, three solid iron bars, which may be readily withdrawn from the foot-plate, being placed at the lowest points for convenience in cleaning the fire. Openings are also made for the insertion of bars for breaking up and raking out clinkers. The clear space between the bars is from ¾ in. to 1 in. The coal is placed upon them in lumps of the size of a man's head. The fire-door, of oval form, is unusually large, say 14 in. deep and 19 in. wide, the outer plate having large air openings, and the inner plate numerous small perforations for the distribution of air. The cylindrical portion of the boiler is 3 ft. 4 in. in diameter, and contains 170 tubes, 11 ft. 5 in. long, 160 tubes being 1¾ in. and ten being 1½ in. in diameter. The tubes are of iron, very thin, and are set without ferrules. The boiler has two steam domes, each 24 in. in diameter and 2 ft. 6 in. high, the steam being drawn equally from each. In the smoke-box the blast pipe is of brass, 6½ in. in diameter inside, and contracted to 4¾ in. at the discharging orifice, which is placed below the lowest row of tubes. It has a hollow frustrum of a cone, with a 2⅝ in. opening, which can be moved within, so as to reduce the discharging opening to that diameter. Immediately over the blast pipe is placed a vertical 9 in. pipe, flared outwardly at the bottom, and rising nearly to the base of the chimney. By means of this pipe, which is open both at the top and bottom, the draught due to the blast is made to draw equally, or nearly so, through all the tubes, whereas, without it, the draught tends more directly to the upper tubes. "This pipe, which, with various modifications, is known in America as the 'petticoat pipe,' has been in use for many years for both coal and wood-burning engines. In a treatise on the Locomotive Engine, published by H. C. Baird, Philadelphia, in 1853, a similar pipe is described in connection with an anthracite coal-burning engine, which, it was stated, was running in the year 1850. 'There is a pipe, about 9 in. in diameter, passing up through the smoke-box, from the bottom to the top, and entering the chimney, leaving a few inches all around it for the smoke to rise through. The exhaust enters this pipe at its bottom, and the partial vacuum created by its action supplies the blast, as in ordinary locomotives.' 'The Locomotive Engine,' by Zerah Colburn, Boston, U. S., 1851, and Philadelphia, 1853. We refer to this subject, inasmuch as a patent for the same arrangement has been recently obtained in England." The chimney is 12 in. in diameter, and a flat plate or damper can be moved at pleasure, so as to wholly or partially close it at the top. Around it there is an outer casing to retain fine coal and cinders, a circular grating, 2 ft. in diameter, being placed over the chimney. This grating is of cast-iron, and consists of a series of bars 1 in. deep, ¼ in. thick, and 5/16 in. apart. From the edge of this grating down to the outer edge of the external casting a coarse wire gauze, with three meshes to the inch, is placed.

"The parts described are those, chiefly, which are more influential in the combustion of the coal. The engine, in other respects, is similar, with few exceptions, to ordinary American locomotives. It was designed and built by Mr. James Millholland, locomotive superintendent of the Philadelphia & Reading Railway."

From the above it can be seen that the function of the petticoat pipe was not to increase or even equalize the draft through the tubes, but simply to serve as a guide for the exhaust jet in its passage from the nozzle to the stack. Note in the B. & O. stack there was an inner stack within the balloon part, but as its purpose is not pertinent to this paper, we will not discuss it. While history apparently indicates that the balloon stack was developed on the B. & O. for use in connection with anthracite coal, yet so far as the writer can learn its use was generally confined to wood-burning locomotives, as this design permitted the use of a very fine mesh netting without unduly restricting the effective netting opening.

With the gradually increased use of coal as locomotive fuel, however, the balloon stack soon gave way to the diamond stack, of which there were many designs and modifications. In this development you will note the petticoat pipe is retained, and many a hot argument was based on the proper seting, overdraft and underdraft, etc. In fact, the author of this paper wrote what he considered an authoritative article on this as far back as 1898, making statements which at that time he believed to be correct, but which in the light of subsequent experience he found were largely imaginary. The back issues of our own Proceedings will show that at one of our Conventions it was decided that the best place for the petticoat pipe was on the back of the tank.

The diamond stack in all its variations was followed by the straight stack and extension front end, and, candidly, it must be admited that some of them were extension fronts indeed. The long extension was presumably a storage place for cinders, as the earlier designs were not of the self-cleaning variety. Hoppers were provided underneath for the discharge of the accumulated cinders, and hand-holes in the sides of the smoke-arch into which crooked pokers could be inserted to poke the cinders out. The need of having the front end joints air-tight was not so fully appreciated in those days, hence the cinders frequently caught fire and you can easily imagine the rest.

Later on a committee composed of prominent members of the Master Mechanics' Association developed at the Purdue University a design which became generally known as the Master Mechanics' standard self-cleaning front end. This design, with which you are all more or less familiar, embraced the diaphragm plate, the table plate, draft sheet, netting and straight stack. While this design was recommended as good standard practice, few followed the exact lines as laid down, but as many individual variations soon appeared as there were types of locomotives: straight stacks, taper stacks, choked stacks, inverted taper, etc.; petticoat pipes, single, double and triple; with and without flares and flounces, draft sheet back of the nozzle and in front of it; nozzle tips of all shapes and dimensions, all with but one end in view, viz., to create the greatest front end vacuum with the least cylinder back pressure, or, in plain English, to make the engines steam without choking them. All this, of course, with the saturated steam engine.

We now come to the advent of superheated steam, and its effect on front end design. The principal change consisted of moving the draft sheet, i.e., the adjustable plate, ahead of the nozzle, and the introduction of the superheater damper; practically all other parts were retained intact. About this time, however, the locomotives grew larger; this meant a reduction of stack height above the smoke-arch or a shortening of the stack. This reduction in external stack height was in a measure compensated by lowering the exhaust stand and in some cases extending the stack down into the smoke-box; in other cases the petticoat pipe, generally out of line with either the nozzle or stack, or both, and supported on flimsy hangers, with its so-called overdraft and underdraft, was religiously adhered to. Zerah Colburn said the space between the top of the petticoat pipe and the base of the arch was to permit the smoke to escape. He never claimed, even in that day when there was nothing between the petticoat pipe and the flues, that the draft could be equalized by increasing or decreasing this opening. We wonder what answer he would make to a present-day engineer who claimed he could regulate the draft in this manner regardless of the interference of diaphragm, table plate, etc. It may be possible, but it is hard to see.

The Pennsylvania Railroad in their Altoona testing plant long ago demonstrated the fallacy of this reasoning. They also proved that it was possible to so dimension the various parts entering into the front end draft appliances that everything could be nailed into place in the back shop; then if the locomotive did not steam, some one would look for the real cause instead of moving draft plates, petticoat pipes, etc. More power to them!

All tests have shown a difference in front end vacuum behind and in front of the diaphragm; the difference depending on the total vacuum. Does this not indicate that the diaphragm plate is an interference? Then why keep it? The Type E Superheater is rapidly coming in, which removes the necessity for a damper, even if it ever were necessary, which some are inclined to question; therefore, why not do away with the diaphragm also, and, while we are at it, with the table plate and petticoat pipe?

Grates

Locomotive grates have been subject to about as many changes as the front end draft appliances, and while possibly due to the variation in the character of the coal used in different parts of the country, it may not be practical to adopt a standard design, yet in the light of recent experiments it would appear that some modification of present types, particularly in stoker-fired engines, may be worth our serious consideration.

Designed originally simply to support the fuel and permit the inflow of the air necessary for its combustion, no particular uniformity appears to obtain insofar as the ratio of air opening to total grate area is concerned, or the relative size of the openings. Furthermore, up to the time of Federal operation it seemed to be an open question as between finger and so-called table grates or modification thereof.

It may be of interest in this connection to remark that in English practice the fixed, i.e. non-rocking grates are generally used, while on this side the rocking grate is favored, and in the opinion of the writer justly so, as in American practice the grate must possess another function in addition to those mentioned above, viz., to permit the easy and rapid cleaning and dumping of fires, removal of clinkers, etc., especially on locomotives used on extended runs.

It is not the purpose of this paper to recommend any radical departures, but simply to call attention to some recent developments on the A. T. & S. F. and Northern Pacific Railroads, believing that the results obtained are well worth careful investigation and consideration as perhaps pointing in a direction heretofore passed unnoticed.

While under ordinary operation there is a difference of only aboht two ohnces in presshre between that in the ash-pan and that in the fire-box, yet this difference is sufficient to set up an air or gas current, if you prefer, having a velocity of approximately twenty miles per hour immediately above the fire, and increasing very rapidly in its passage to the flues. A blast of this velocity is capable of lifting and carrying with it quite large particles of coal, and especially where the grate openings are fairly large and so spaced as to permit the formation of holes through the fire-bed, can be considered the direct cause of the stack loss due to the discharge of unburned or partially burned coal commonly called cinders. Would it not therefore appear that a grate having fixed openings, small in size and equally spaced, would be the logical grate to apply?

In a foregoing paragraph we mentioned stoker-fired engines. With engines hand-fired the type of grate or size of air openings is not of as much importance; as generally the lumps of coal fired are larger, and, again, as the fireman looks at his fire with each supply of coal he can readily fill up any holes as fast as formed. Furthermore, knowing that too much air admitted is just as detrimental from a combustion standpoint as not enough, he restricts this flow by increasing the depth of the fire, as necessary. Again, as a man can only shovel a certain amount of coal in a given time, he must of necessity carry a fire of sufficient depth to meet any emergency.

Stoker firing is an entirely different proposition, however. In the first place the coal is reduced to a size best adapted for mechanical distribution. Naturally, in crushing lump coal to these dimensions, more fines—one-quarter inch or less—are produced than where the lumps are broken with a coal pick. The fire in stoker-fired engines should be carried much thinner also, as all stokers have sufficient reserve capacity to meet any sudden demand, thus obviating the necessity of heavy fires; therefore it would appear that the grate best adapted for stoker firing is one that will permit carrying a very light fire without the possibility of too much waste through the grates or the possibility of tearing holes through the fire no matter how thin, or even admitting too much air should any part of the grate surface be actually uncovered. Remember, in stoker firing the fireman is not checking the condition of his fire at frequent intervals, as in hand firing, and therefore the possibilities of an uneven are are much greater. Therefore, is it not logical to so design the grate as to reduce the detrimental effect of uneven fires—banks and holes—to a minimum?

The amount of air opening through the grates has long been a mooted question, ranging in hand-fired engines from twenty-two to fifty-five per cent of the total grate area. Experiments on the Santa Fe and Northern Pacific with practically all kinds of coal, excepting anthracite and including lignite, would indicate, however, that with a fire carried at the proper depth, a grate having a ratio of from twelve to eighteen per cent small openings equally spaced—will not only admit enough air under practically all conditions and with any kind of bituminous or related coals, but at the same time reduce the possibility of an over-supply. The experiments have also apparently demonstrated that such a grate reduces the stack loss, particularly in stoker-fired engines, as well as the formation of clinkers; that the fire can be kept at the right depth just as easily as with other types of grates, and be cleaned as readily at terminals or where necessary. At any rate, it would appear that this type of grate is worth looking into as another item of design affecting locomotive operation. Think this over.

There is another and a rather compelling reason that should cause us to consider the adoption of a grate with smaller air openings, viz., the possibility of taking advantage of the market and burning screenings when they are available at a price sufficiently below that of mine-run coal to justify. Screenings make an ideal stoker fuel, although not well adapted for hand-firing, but even if used in connection with a stoker it is necessary to have a properly designed grate in order to realize the fullest possible economy.

Brick Arches

While not covered in the heading of this paper, and while, strictly speaking, the brick arch cannot be considered a draft appliance, yet as an improperly designed or improperly applied brick arch has such a material effect on locomotive operation (when we speak of locomotive operation, we, of course, refer to everything that pertains thereto, such as fuel economy, etc.), we think it well to refer briefly to this very important adjunct.

History repeats itself. When the first railway charters were granted in England, it was stipulated that the locomotives must make no noise and no smoke. Therefore, on such railroads where smokeless coal was available, this coal was generally used. On other roads tapping coking coal fields, coke was used. Along in 1847, however, they had a miners' strike in the coking coal fields. Railroads that had used coke could not always obtain a sufficient supply of smokeless coal, so they began devising means to overcome the smoke when burning smoking or high volatile coals. The result was the brick arch.

In the early development of railroads in the United States apparently no objections were raised to either noise or smoke. Therefore, while in the beginning some roads followed English practice insofar as the application of brick arches is concerned, not so much to eliminate smoke, but because the more progressive railroad officers realized the fuel economies obtainable through its application, yet owing to the difficulty in maintaining arches (generally supported on studs tapped into the side sheets), the general use of the arch was later discontinued, and not revived until an arch was designed supported on arch tubes, as is our present practice. Even then it is doubtful if the arch would have been generally adopted had it not been for the universal campaign, especially by large cities, for smoke abatement.

The railroads applying brick arches with this end in view soon found that, in addition to reduced smoke, very material economies in fuel were also obtained. This fact was stressed by the International Railway Fuel Association, and later by the Fuel Conservation Section during Railway Administration days, so that practically all railroads fell into line, until now it is more uncommon to see a locomotive without a brick arch than to formerly see a locomotive with one.

In the design and application of brick arches, however, the same lack of uniformity appears to obtain as with grates, front end draft appliances, etc. It was at one time considered good practice, and a practice which in many cases is still adhered to, to use a spacer brick between the arch and the throat-sheet so as to leave an opening varying anywhere from three and one-half to ten inches, presumably on the theory that as the draft carried the cinders over the top of the arch they would fall down again through this opening and so be consumed, or on the theory that if the arch was against the throat-sheet making what is called a sealed arch, cinders would collect on top of the arch and stop up the lower flues. Both of these theories, however, apparently have little if any foundation in fact. On the contrary, the open arch was one of the most prolific causes of flue leakage.

In the earlier locomotives the brick arch was not extended back as far as might have been economically advisable, as any rearward extension had a tendency to throw the flame back correspondingly, resulting in there being so much heat at the firedoor that locomotives could not be hand-fired with any degree of comfort. Therefore, arches were kept moderately short.

With the advent of the mechanical stoker, however, the same objections could not be raised against bringing the flame back against the door-sheet so as to obtain the full benefit of all the fire-box heating surface. It was also found that owing to the tendency of the finer particles of coal being carried further that a bank was liable to form where the open arch was used. Therefore, in order to settle the question as to the best design of brick arch, taking everything into consideration, i.e., fuel economy, smoke elimination, evaporation per pound of coal due to increased fire-box temperature, etc., tests were conducted, and it was found that a sealed arch, extended back until the opening between the top of the arch and the crown-sheet was equivalent to about 115 per cent of the total flue area, a reduction in fuel consumption ranging from 10 to 15 per cent would be obtained over an open and short arch wherein the opening between the top of the arch and the crown-sheet was equivalent to from two to two and one-half times the total flue area.

We believe this is a subject well worth your serious consideration.

Ash-Pans

Obviously, ash-pans were originally applied as a receptacle for the ashes shaken through the grates. There is no need to go into the development of the ash-pan, as naturally it had to change with the change in locomotive construction, but apparently some designers are still of the opinion that the only purpose of the ash-pan is that for which originally intended, viz., a receptacle for ashes, and apparently not realizing that it is one of the most important adjuncts affecting combustion that is placed on the locomotive. In the beginning of this article we spoke of the draft appliances located in the front end, whose function was to maintain a partial vacuum in the fire-box. The amount of vacuum necessary in the fire-box to burn fuel at a certain rate depends, of course, on the difference in pressure above and below the grates. The fact was also mentioned that under ordinary operating conditions the pressure in the fire-box is only about two inches less than that of the surrounding atmosphere. If, therefore, the ash-pan is so designed that sufficient air cannot flow under the grates to maintain atmospheric pressure, it follows that in order to obtain the necessary difference in pressure a higher vacuum must be created in the fire-box, and this, as previously shown, is usually obtained by reducing the nozzle, which, in turn, results in higher back pressure and so affects locomotive operation.

It has generally been recognized that an ash-pan air-opening equivalent to 14 per cent of the total grate area is sufficient under practically all conditions to maintain atmospheric pressure under the grates. Some very recent tests have demonstrated, however, that even with this ratio of air opening a partial vacuum equal to .6 inches of water frequently occurs under the grates under certain operating conditions, and, of course, this partial vacuum under the grate is equivalent to reducing the vacuum above the grate by an equal amount. Therefore it might be well to take this into consideration, and in designing ash-pans increase the effective air opening to, say, 16 per cent of the grate area instead of 14 per cent.

With the present-day wide fire-box extending beyond the frame, it is sometimes quite a difficult matter to develop an entirely satisfactory ash-pan; the construction of what is termed the cradle casting being such as to make it necessary to pinch the center of the pan in so as to permit it to come between the frame, and then flare it out to the width of the mud ring or a little beyond. Therefore if the pan is dropped far enough below the mud ring to obtain the necessary air opening, it often follows that the flare of the pan has not sufficient slope to permit the ashes to slide down into the tapered part of the pan, and particularly where the grate connecting rods are brought well out from a center line; the result being that where the design of the pan shows plenty of air opening so long as the pan is clean, yet as soon as the grates are shaken once or twice there will be enough ashes accumulate on the comparatively flat surfaces to very materially restrict the inflow of air, and in this way defeat the very purpose aimed at when dropping the pan below the mud-ring.

Inasmuch as the lack of sufficient air under the grate so very materially affects combustion, coal consumption, steaming of the engine, etc., it would appear that a little more consideration could be given to the ash-pan design, with a view to developing one that will meet every requirement.

Coal Gates

It might sound like a far cry from the design of a coal gate to locomotive operation, but when we stop to consider a recent case wherein an important passenger train pulled by a hand-fired engine was delayed 40 minutes due to the design of the coal gate (of course, the size of the coal also entered into the proposition), is shows that there is, nevertheless, a very intimate relation between the two.

It has been observed that in recent construction a type of practically solid sheet iron coal gate is favored. Usually they are made in four sections, in the form of gates swinging inward. Re-enforcing strips in the shape of angel irons are riveted to the inner sides of the gates. There is no question but that a gate of this construction is strong, substantial and effective insofar as preventing the loss of coal from the gangway is concerned, regardless of whether the tender is loaded with lump, mine-run, or screenings.

There is another factor to be taken into consideration in this connection, however, besides a gate that forms an effective barrier against the loss of coal, viz., the possibilities of train delays when such a gate is used in connection with a stoker-fired engine, due to the arching of the lumps of coal over the conveyor or trough, and the fact that when these lumps do arch in this manner, particularly if it should occur when the tender is carrying practically a full load of coal, it is often almost impossible to break the arch down so that coal will again feed into the conveyor trough.

During the war there was a form of coal gate developed and used on locomotives built for the Government, termed the Dunham Gate. This consisted of a series of heavy planks set into pockets on each side of the coal space, being set at an angle so that each of the boards which extended clear across the coal space, sloped back, leaving a space between the bottom of one plank and the top of the next through which a shaker bar could be used for breaking down any lumps that were too large to pass under the lower board.

We are now advocating the return of this type of gate, but believed that the principle involved might with profit be incorporated in the iron gates now being used. At any rate, if there would be objections toward incorporating this principle, the angle iron re-enforcing pieces could at least be moved from the back to the front side of the coal gate where they would be equally as effective as stiffeners, would serve as toe-holds when one wished to climb over the gates, and when so located would remove what practically forms a series of shelves when placed on the inside, which shelves go far toward causing the arching of lump coal above referred to. It is a little thing, but locomotive operation is made up of a series of little things. Sometimes the loss of a cotter key results in an engine failure.

The location of a coal gate at times also affects locomotive operation, as, for instance, if the coal gate is located immediately above the crushing zone in the stoker conveying mechanism, it is a hard matter to exclude tramp iron from the coal. If the tender is fully loaded and a piece of tramp iron too large to pass through the crusher happens to feed into the coal, it is often a difficult matter to remove the obstruction where the coal gate is located too far ahead. The amount of coal space sacrificed by placing the coal gate a little further back, or at least angling them back at the center, is negligible compared with the possibility of overcoming train delays due to tramp iron getting caught in the crusher.

The locomotive is becoming a more intricate machine with each new design developed, and in designing a present-day locomotive it is rather difficult at times to find a get-at-able location for the various auxiliary devices; consequently, in looking after the major parts, minor parts are sometimes overlooked insofar as design or location is concerned, until service demonstrates their importance. In the above paper we simply wish to call attention to a few of the so-called minor matters, which often assume major importance when the locomotive is in operation. We believe a full and free discussion of the points brought out would be well worth a little of the time of this Association. As stated in the beginning, there will no doubt be differences of opinion, and some of the points will be considered as ultra-radical. However, they may contain the germ of an idea which your discussion may develop into something practical, and something that will help to improve locomotive engine service on American railroads.

Welded Metal Railroad Ties Used on Switches

Another stimulus to the consideration, by railroads, of the substitution of metal for wooden railroad ties is expected as a result of the application of welded metal ties to switches and cross-overs by the Delaware & Hudson Railroad. This company has recently completed the rearrangement of the spur which connects its main freight line with the General Electric plant at Schenectady, and all the old wooden ties were replaced by the metal variety.

The Delaware & Hudson Railroad installed machinery at its Colonie N. Y., shops for welding metal ties, and a section of track in its freight yards at that point was laid with welded metal ties fabricated from worn rails.

Until recently, however, such ties had been used on straight track only. The installation at the General Electric plant in Schenectady includes all types of track which are commonly used in railroad service, with the exception of track involving the signaling function on which development work is now in progress. Switches, crossovers and switch-stands are mounted on metal ties.

For this special construction, scrap rails, cut to the proper lengths, were delivered on the spot and there welded by hand and installed under the track. The railroad crew foreman in charge of the installation claimed that not only was the work simplified with the metal tie, but that he could do a much better job with more permanent, beneficial results.

A particularly advantageous consideration, it was found, developed in connection with the installation of the crossovers. Where one track left another at a switch, metal ties of greater length were used, a single tie being common to both sets of track for quite a distance from the switch. It is believed by Delaware & Hudson experts that this affords quite an important saving over the cost covering a similar practice using wooden ties. The value of using single ties common to both sets of track in such applications lies in the stabilizing effect at a point subjected to particularly heavy stresses, thus tending to provide a firm, strong switch with no tendency to weave or tilt out of position.

The Delaware & Hudson's metal tie fabricating shop at Colonie, N. Y., has at present an output of about 20,000 ties per year which is entirely covered by requisitions from the various operating divisions. Metal ties are now considered standard by the Delaware & Hudson Railroad for everything except signal track.

Notes on the Introduction of Steel in Railway Equipment

When the railways commenced to substitute steel for wood in car construction some twenty years ago, there was so much favorable comment and publicity given the matter that most of the present generation, and not quite a few of the older set of railway men actually believe that steel was first introduced in car construction about 1900, and as a matter of fact, there have been some who have taken credit for having originated certain features that were in fact employed before they were born.

By a casual review of state of the art we find that steel or iron plates were used in car construction some 40 years or more prior to 1900.

In reviewing the history of American railroad equipment the locomotive naturally is given the larger share of attention, but the strides and attempts at improvements in cars have been important.

The year 1854 brought forth one of these when on April 4th a patent was granted to B. J. LaMothe, M. D., of New York City on an "Improvement in Railroad Cars." The claim of this patent were for building cars of continuous longitudinal and transverse "elastic steel bands" whereby passenger cars would be practically fireproof and lighter in weight than the wooden ones then in use.

Dr. LaMothe secured the services of a stock promoter to finance his ideas. They succeeded in getting enough capital to build several passenger and freight cars.

In 1859 the first iron passenger car was completed at the shop of Wm. Cundell, Paterson, N. J. Mr. Cundell conducted a sheet iron and tinsmith business primarily to supply the various locomotive builders of Paterson with smoke stacks, head lights, stamped brass letter and numbers, boiler jacketting and ornamentations thought necessary in those days by railroads. The car could accommodate 60 passengers being 46 feet long and 8 feet 4 inches wide over the frame with a total length over platform of 51 feet 6 inches. The interior was handsomely finished, including four large mirrors with gilt frames, 30 large windows with brass sashes and curtains of handsome English reps, hat racks of the largest pattern, 28 ventilators with opaque glass, black walnut and gilt mouldings, and many papier mache decorations in the panels.

The framework of the car was composed of iron bands from two to five inches wide running continuous from end to end and around the body similar to a wicker basket. The spine or center sill was composed of three 6 in. bands placed vertical with 1½ in. oak fillers between, the whole being riveted at each point where the longitudinal bands crossed the vertical ones. The remaining space was filled in with thin metal panels. The roof was of galvanized iron.

The car was run on the Erie Railroad experimentally, and proving successful, was accepted by the original purchasers, The Boston and Worcester Railroad.

The desire to make the body strong enough caused the designers to provide windows too small for comfort and this detail was changed in the next coach built.

The next two cars were finished the early part of 1861. They were combination freight and passenger much smaller than the Boston and Worcester coach and built of corrugated iron instead of bands and sheets.

The last car built was for the Hackensack and New York Railroad and like its predecessor on the Boston and Worcester was constructed of band and iron sheets.

The roof and sides were lined with felt to insulate the heat and cold. The interior was finished in black walnut, gilt and oak graining, but lacked the handsome mirrors and pictures of the Boston and Worcester car. A new style seat was used in which the back could be placed at any desired inclination.

This car was mounted on 6 ft. gauge trucks which was the prevailing gauge on the Erie, and Hackensack and New York Railroads at that time. The springs were of heavy India rubber and the car sat squarely without any sagging which caused much wonder as everyone expected it to bend slightly from its great length.

The Hackensack and New York Railroad was completed the latter part of 1860, running in a straight and level line about six miles from Hackensack to a junction with the Erie main line near Boiling Springs, now Rutherford, N. J. In February 1861 their equipment consisted of one tank engine named HACKENSACK, one first class passenger engine BERGEN, and one first class iron passenger car. The two iron combined cars were in use on the Lodi branch hauled by mules and later by a 0-4-0 wood burner.

On February 21, 1861 "a new locomotive named BERGEN was run for the first time with a train including the iron car to carry the crowds from Hackensack to Jersey City to see "Old Abe" " who was on a roundabout trip from his home in Springfield, Ill., to Washington where the inauguration would take place the following month.

Business on the Hackensack and New York was booming at that time and orders were let for one more iron passenger car and one wooden car.

In the use of iron for freight cars, one of the earlier instances was a powder car built for the Nashville & Chattanooga Railroad in 1862, and used by Generals, Hooker, Hood and Sherman during the Civil War.

General Hood of the Confederate army, when hard pressed by Sherman dumped the car into the Etowah River from which it was later fished out becoming a part of the rolling stock of the N. & C. Railway, being used as a baggage and express car and later by the superintendent of construction.

In English practice, we find the use of metal plates going back more than fifty years. Among the first we find the designs of one Gedge in 1876 in which metal plates or sheets were employed in place of wood and to give maximum of strength to prevent bulging the plate were corrugated. Such corrugations were used in the construction of the passenger cars in United States in 1861, or some fourteen years earlier.

We are living in an "age of steel," and its use will no doubt be extended in many lines particularly in the railway field, but in giving credit to those who discover new uses or methods of use, we should not fail to make belated or tardy acknowledgment for certain designs or uses which while claimed to be new, were old when some of the claimants were born.

The Motive Power of the Boston & Maine and Maine Central Railroads

By ARTHUR CURRAN

Recent references to railroading in the northeastern states have occasioned a demand for a few words about two of the lines not mentioned hitherto. These are, of course, the Boston & Maine and the Maine Central.

Readers who are interested in purely statistical information may obtain plenty of it through the usual channels. The present paper is concerned only with such notes as are in harmony with the previous article of this series.

To begin with, the Boston & Maine presents one of the most interesting developments of recent times. Confronted by motor competition on the highways which rendered some of its branches and short lines unprofitable, it made a bid for through business by putting on some pretty speedy passenger trains and by building up-to-date freight yards capable of handling a large volume of traffic with efficiency and despatch. In fact, since President Hannauer took charge, even the newspapers have been forced to admit that a vast improvement has resulted.

The motive power policy of the road has been conservative for many years, though modern types of locomotives are used on all of the important services. Up to recent times, however, the engines have been of moderate weight and devoid of the doodads which loom so large on some other roads.

For example, Class P 2 A was for many years about the largest for passenger service on the road. These engines are of the Pacific type, and were built at the Schenectady Works of the American Locomotive Company in 1911.

Principal dimensions are as follows: Cylinders, 22 x 28 inches; drivers, 73 inches in diameter; weight of engine, 235,000 lbs.; boiler pressure, 200 lbs.; tractive power, 31,600 lbs.

The boiler is of the straight type, 70 inches in diameter at front end, and has a centrally-located dome. The grate area is 53.2 square feet, a very good figure for a boiler of this size.

The general design does not call for extended comment, but is neat and well-proportioned.

A later design, represented by locomotive No. 3683, included some minor modifications and has a new style of tender with shallow tank and high collar. An attractive innovation is the railroad company's trade-mark, which appears on each side of the tank.

A couple of these engines were finished in buff and blue. Plain blue and would have been better; as, of course, the buff does not wear well.

The engine shown herewith is finished in black, with the exception of number and trade-mark, as already mentioned. It must be admitted that the general appearance is excellent. Certainly, the class looks very fine in service.

Recent newspaper references to the average of 46.1 m.p.h. of the Flying Yankee confirm the belief that the B. & M. has "made a hit."

It is necessary to add, however, that this creditable result is achieved on a line which presents many obstacles to high speed. Slow order track, grade-crossings, stations in "tight places," curves and various other factors handicap the engines. Otherwise, an average well above 50 m.p.h. would be possible.

Locomotive No. 3683 of the Boston & Maine Railroad

The Minute Man, with steel coaches, Pullmans and observation car, makes a fine appearance and affords convenient service.

It would require too much space to describe in detail the improvements in freight service. It is sufficient at this time, to remark that Consolidation, Santa Fe and other types of locomotives are used, and that car-retarders and many other devices are brought into play to speed up, with safety, the work which must be done.

At certain points, it is rather difficult to police the road, and one or two "spills" have resulted as a consequence. Drastic measures will be required to remedy this situation; as, no doubt, the management are well aware. In this work, the good wishes of all right-minded citizens will follow the officers.

On various occasions, accounts of old times on the Maine Central have appeared; but very little has been published of the road's later doings. The passenger business of the line is greatest during the summer, at which season trains of considerable weight are handled at smart rates of speed.

Many years ago, the Maine Central recognized the possibilities of the Pacific type; though the early examples on the road were of very moderate size, and photographs of them are not, at the moment, available.

Subsequent to their introduction, a class slightly suggesting the early B. & M. design was placed in service. Principal dimensions of this class are as follows: Cylinders, 22 x 28 inches; drivers, 73 inches in diameter; weight of engine, 228,500 lbs.; boiler pressure, 200 lbs.; tractive power, 31,600 lbs. The boiler is of the straight type, 70 inches in diameter at front end; but the dome is not centrally-located and the grate area is 50.2 square feet.

In due course, a larger design appeared. Still later—in 1918, to be exact—the Pacific class of the now familiar style was placed in service. These engines were built at the Schenectady Works of the American Locomotive Company, and have cylinders 25 x 28 inches, 73 inch drivers, and weight of 260,000 lbs. The class is represented by locomotive No. 470. The boiler is of the wagon-top type; and the design, as a whole, is noticeably massive.

Among the freight engines on the road, the Mikado type, of the erstwhile administration standard, need no particular mention; albeit the design was not a bad one, and gave good service on a number of lines.

Pacific Type Locomotive No. 470 of the Maine Central Railroad

A considerable number of 4-6-0 engines were in use at one time, of which some may still remain. Due to the seasonal nature of the traffic, a considerable variety of motive power classes may find assignments.

Recent statements that passenger traffic on American railroads is decreasing do not specify the kind of traffic. So far as can be judged, the decrease is in the short-haul business, which never was profitable, anyway!

The fact that fast, through trains are well-patronized all over the country encourages the belief that the "cream" of the passenger business will remain on rails. In any case, the two roads mentioned in this article are doing what is possible to keep desirable traffic.

Acknowledgments are due to Mr. George P. Becker, for photographs kindly placed at my disposal.

Turbine-Electric Car Ferries on the Great Lakes

Two high-speed car ferries to be operated on the Great Lakes by the Pere Marquette Railroad are expected to effect a reduction in time consumed in shipping by that route, according to a recent announcement. These ferries will be driven at a rate of 18 miles per hour by turbine-electric propulsion equipment, the first application of electric drive to this type of craft.

The new ferries will operate on Lake Michigan between Ludington, Michigan, and points in Wisconsin. Runs will vary in length from 60 to 100 miles. In order to achieve the high speeds for which the boats are designed, they will be equipped by the General Electric Co. with power plants capable of developing more horsepower than any other boat on the Great Lakes.

The boats will be built by the Manitowoc Shipbuilding Corporation of Manitowoc, Wisconsin. Electric equipment for propulsion and the operation of auxiliaries will be supplied by the General Electric Company. Each boat will have a draft of approximately 16 feet and will be designed to carry 28 42-foot railroad cars.

The cars carried will consist mainly of the freight type. The design of the boat will be standard for this type of service, but will also include features allowing operating during the winter months when ice breaking will be necessary. The power plant and other machinery will be located amidships.

Each boat will be of twin-screw design. Two turbine generators on each boat will each be capable of furnishing propulsion and auxiliary power sufficient to operate all the electric equipment on the ship, including propulsion motors, auxiliary devices and lighting. Each propeller will be driven by a 3600-horsepower, 120-r.p.m., 2300-volt, slip-ring induction motor. These motors will be of the type of construction used in mill service on land, in order to withstand the severe duty encountered in ice breaking service.

The generators will distribute power at 2300 volts direct to the motors and, for auxiliary purposes and lighting to transformers and a 3-unit motor-generator set on each boat. By operating the auxiliaries from the main power plant, advantage is taken of the low water rate and economical steam conditions of the propulsion turbine. This turbine will operate at a pressure of 300 pounds gauge, 200 deg. F. superheat and 28½ inches vacuum.

The electrification of auxiliaries includes an aggregate of approximately 600 horsepower in electric motors on each boat, driving such machines as main circulating pumps, main boiler feed pumps, fresh water circulating pumps, sanitary pumps, bilge pumps, capstans, windlasses, winches, etc. For use during long periods at port, there will be a 150-kilowatt auxiliary generator to apply power for operating lights and those auxiliaries which it will be necessary to keep in service on such occasions.

The propulsion machinery will be controlled by a combination of varying turbine speeds and varying resistance in the secondary circuits of the propulsion motors. The control devices, suitable instruments, etc., will be mounted on a single-panel switchboard to be located in the engine room. There will also be a smaller switchboard for the auxiliary generator and distribution system circuits.

This application will be of particular interest in Great Lakes shipping circles, as the first turbine-electric ship propulsion application in this country was made on the Great Lakes, involving the electrification of two fire boats for the city of Chicago. The electric car ferries will also be the first of their kind.

With the two new boats, the total number of turbine-electric craft on the Great Lakes will be six. In addition to the two Chicago fire boats, there are also two self-unloading cargo carriers owned by the Bradley Transportation Company. All of these ships are equipped with General Electric turbine-electric drive. There are also four Diesel-electric boats on the Great Lakes, making the total number of electric ships in that service, including the car ferries, ten.

No Further Orders for Automatic Train Control

The Interstate Commerce Commission will not order the railroads to make further installations of automatic train-control devices or of block signals at the present time, according to a decision announced on November 28.

The Commission cited what it called the appalling increase in fatalities and injuries in grade-crossing accidents resulting from the huge gain in automobile traffic in the last few years as one reason for its decision, and the conclusion was reached by the majority that concentration of effort for the removal of grade crossings, track and bridge repair, and the abandonment of wooden cars would accomplish more to reduce deaths attributable to railroad operation than any other steps that might be taken.

The majority of the members of the Commission indicated their belief that the railroads would go ahead voluntarily with plans for the installation of automatic safety systems. Commissioner Eastman dissented in part from the decision.

Two orders have heretofore been issued by the Commission regarding the installation of safety devices, the first on June 30, 1922, and the second on January 14, 1924. These orders covered 8,388 miles or road, 15,175 miles of track and 7,408 locomotives. This work has been practically completed by the carriers. Installations required under the two orders as of May 1, 1928, have been made on 8,308 miles of road, 15,002 miles of track and 7,345 locomotives.

The Commission quoted figures in its decision showing that the number of persons killed and injured in grade-crossing accidents in the United States for the years 1923-1927, inclusive, totaled 11,485 and 32,998 respectively, and added that "there can be no question as to the seriousness of the highway grade-crossing problem as presented in the foregoing figures."

"It has been shown in this case that the number of accidents and casualties which result from disregard of fixed signal indications is relatively small in comparison with those which result from other causes set forth in this record," said the Commission. "We therefore believe that vigorous efforts to provide adequate protection against the larger number of accidents which arise from such causes will afford a far greater measure of safety than requiring by order special efforts to extend train-control installations. For that reason we have concluded not to require by order at the present time further installations of train-stop or train-control devices.

"The carriers should be diligent in their efforts to provide adequate protection against accidents due to grade crossings, derailments, collisions in territory not protected by block signals, failure of wooden bridges and trestles, and the use of wooden passenger train cars, which have been repeatedly mentioned in our recommendations to the Congress. This in no way relieves the carriers from the responsibility which rests on them to provide additional protection where needed in territory now equipped with block signals.

"We shall therefore expect them to undertake the necessary studies and tests to bring about standardization of design and method of installation of train-stop and train-control devices so that they may be used in terminal areas and on joint track where traffic density is greatest without the necessity of expensive and inconvenient duplication of locomotive or wayside equipment."

Notes on Domestic Railroads

Locomotives

The Belt Railway of Chicago has ordered 5 eight-wheel switching locomotives from the Baldwin Locomotive Works.

The National Railways of Mexico has ordered 6 Mallet 2-6-6-2 type locomotives from the American Locomotive Company.

The New York Central Lines has ordered 55 locomotives and 5 additional 15,000 gal. locomotive tenders from the American Locomotive Company, to cost about $5,400,000. Of these 30 will be of the Hudson type for passenger service and 25 Mohawk heavy type for freight service. These are for service as follows: New York Central, 25 passenger locomotives; Michigan Central, 5 passenger locomotives, and Cleveland, Cincinnati, Chicago & St. Louis, 25 freight locomotives. The Hudson type locomotives will have 25 by 28 in. cylinders and a total weight in working order of 350,000 lb.; the Mohawk type will have 27 by 30 in. cylinders and a total weight in working order of 363,000 lb.

The Illinois Terminal Company is inquiring for 1 Mikado type locomotive.

The Hu Len Hei Lun (China) is inquiring through the builders for 5 Mikado type locomotives.

The Canadian National Railways has ordered 20 locomotives of the 4-8-4 Northern type, from the American Locomotive Company through the Montreal Locomotive Works, Ltd. These locomotives are of the same general design as the 6100 class and will be used for both freight and passenger service. An additional order for 10 eight-wheel switching locomotives has been given to the American Locomotive Company through the Montreal Locomotive Works, Ltd., and an order for 15 Santa Fe type locomotives and 10 eight-wheel switching locomotives has been given to the Canadian Locomotive Company. The railway is inquiring for 5 additional locomotives, of a modified design from the Mountain type, now used on main line for both freight and passenger service.

The Solvay Process Company, Syracuse, N. Y., has ordered 2, 0-4-0 tank locomotives, from the American Locomotive Company. These locomotives will have 13 by 20 in. cylinders and a total weight in working order of 65,000 lb.

The Erie Railroad has ordered one 300-hp. oil-electric locomotive to be manufactured jointly by the Ingersoll-Rand Company, the General Electric Company and the American Locomotive Company.

The Denver & Rio Grande Western Railroad is inquiring for 10 locomotives of the 4-8-4 type.

The Texas Company has ordered one six-wheel switching locomotive from Baldwin Locomotive Works.

F. C. Cochabama, Santa Cruz, Bolivia, has ordered two Mikado type locomotives from the American Locomotive Company.

The Buenos Ayres & Pacific (Argentine) is inquiring through the builders for 8 Mikado type locomotives.

The Argentine State Railways contemplate buying about 60 locomotives.

The Central Vermont Railway has ordered 2 locomotives of the 2-10-4 type from the American Locomotive Company.

The Algoma Central is inquiring for two 2-10-2 type locomotives.

The Great Northern Railway is inquiring for 10 Mallet type locomotives.

The Northwestern Railway of India, has given an order to the General Electric Co. Ltd., London, England, for 2 Diesel-electric locomotives. They are of the 0-4-4-0 type.

Passenger Cars

The Pennsylvania Railroad has ordered 200 all-steel passenger train refrigerator cars from American Car & Foundry Co., 200 from Pressed Steel Car Co., 100 from Pullman Car & Mfg. Corporation and 50 from General American Car Co.

The Chicago, Milwaukee, St. Paul & Pacific Railway has placed an order with the Railway Locomotive Company, Chicago, for a high pressure steam motor car equipped with a 450 hp. Locomotor power plant of the International Harvester type. The car body, a 61 ft. baggage and mail car with 12 ft. of the floor space required for power plant units, will be constructed by the Pullman Car and Manufacturing Corp. The total weight of the car and power plant is 100,000 lb. The car is designed to handle two or three trailers.

The Southern Pacific System contemplates buying about 25 dining cars.

The Canadian National Railways is inquiring for 25 first class coaches, 16 sleeping cars and 2 combination baggage and smoking cars.

The Northern Pacific Railway is inquiring for one business car.

The Northwestern Pacific Railway is inquiring for five electric cars and five trailers.

The Chesapeake & Ohio Railway is inquiring for 2 steel dining cars.

The Denver & Rio Grande Western Railroad is inquiring for 4 dining cars.

The Alaska Railroad is inquiring for two second-hand or new passenger coaches.

The Bangor & Aroostook Railroad has ordered 2 combination baggage and mail cars from the Osgood-Bradley Car Company.

The Louisiana & Arkansas Railway has ordered one passenger and baggage gasoline rail car from the J. G. Brill Company.

The Chicago, Burlington & Quincy Railroad will build 33 steel suburban passenger cars at its Aurora, Ill., shops.

The Central of Georgia Railway has ordered one combination passenger and baggage, Model 55, gasoline rail motor car, from the J. G. Brill Company.

The Chilean State Railways have made inquiry for 20 coaches and six sleeping cars. Bids will be received Nov. 23.

Freight Cars

The Sanitary District of Chicago has ordered 16 air dump cars of 30 cu. yd. capacity, and 4 air dump cars of 20 cu. yd. capacity, from the Magor Car Corporation.

The Wabash Railway has ordered 10 hopper cars from the American Car & Foundry Company.

The Canadian National Railways is inquiring for 1,500 box cars and 30 tank cars.

The Anglo-Mexican Petroleum Co., Ltd., is inquiring for 8 tank cars of 7,000 gal. capacity.

The Union Tank Line is inquiring for 100 to 200 tank cars, of 10,000 gallons capacity, and for 100 to 200 tank cars of 5,500 gal. capacity.

The Canadian National Railways has ordered 3 steel combination baggage and mail cars from the American Car & Foundry Co.

The New York, New Haven & Hartford Railroad has ordered 10 transformer cars of 182,000 lbs. capacity, from the Osgood-Bradley Car Company.

The Cerro De Pasco Copper Corporation, New York, has ordered 20 freight cars from the American Car & Foundry Co.

The South Porto Rico Sugar Company has ordered 10 cane cars and 20 flat cars of 30 tons capacity, from the Magor Car Corporation.

The Central Vermont Railway is inquiring for 500 automobile cars, of the rear end load type.

The International Railways of Central America have ordered 25 banana cars of 60 tons capacity, from the Magor Car Corporation.

The Freeport Sulphur Company, New York, is inquiring for 15 steel hopper car bodies.

The American Railroad of Porto Rico has ordered 100 cane cars from the Gregg Company, Ltd.

Supply Trade Notes

The O. B. Capps, Inc., with offices in the Graybar building, 420 Lexington avenue, New York City, has been appointed eastern representative of **The Prime Manufacturing Company**, Milwaukee, Wis.

J. F. Hoerner, assistant to vice-president of the **Baldwin Locomotive Works**, at New York, has been appointed manager, in charge of the New York office, of the Baldwin Locomotive Works and the **Standard Steel Works Company**, succeeding James McNaughton, vice-president, deceased.

L. S. Walker has been appointed eastern manager of **The P. & M. Company** with headquarters at New York, to succeed **F. N. Bayliss**.

W. W. Fetner has been appointed southwestern representative of the **Ulster Iron Works**, with headquarters at 1941 Railway Exchange building, St. Louis, Mo., to succeed **L. S. Hassman**, who resigned recently.

Howard F. Kulas, secretary and in charge of production and manufacturing of the **Midland Steel Products Company**, Cleveland, Ohio, has been appointed vice-president in charge of sales. **J. E. Maloney**, sales manager of the Cleveland division, has been appointed general sales manager.

W. E. Tierney has been appointed representative in the South and Southwest of **The Botfield Refractories Company**, Philadelphia, Pa. Mr. Tierney will have his headquarters at New Orleans, La.

The Lincoln Electric Company, Cleveland, Ohio, has opened an office at 533 Market Street, San Francisco, Cal., with **W. S. Steward** in charge. **L. P. Henderson**, formerly of the Chicago office has been placed in charge of the Minneapolis district. **Robert Notvest** has been transferred from Kansas City, Mo., to Indianapolis, Ind., where he will have charge of the Indianapolis district. He will be succeeded by **R. E. Mason**. **N. L. Nye** has been appointed representative at Akron, Ohio.

August Wilks has been appointed works manager of the **Kearney & Trecker Corporation**, Milwaukee, Wis., and **C. M. Cheadle, Jr.**, has been appointed advertising manager.

R. K. Weber, vice-president of the **Mt. Vernon Car Manufacturing Company**, Mt. Vernon, Ill., has been elected president to succeed **W. C. Arthurs**, deceased and will be succeeded by **H. H. Cust**, assistant to the president.

The Paige & Jones Chemical Company of New York City and Hammond, Ind., has purchased from the **American Water Softener Company**, Philadelphia, patent rights and good-will pertaining to the lime soda water softening business of that company, and will hereafter manufacture and sell this type of lime soda water softeners. **W. T. Runcie**, formerly sales manager and **H. C. Waugh**, engineer of the American Company have joined the organization of the **Paige & Jones Chemical Company**.

The St. Louis Car Company, St. Louis, Mo., has organized the **Cardinal Aircraft Corporation** as a subsidiary to build airplanes and parts. The capital, plant facilities and executive staff for this new department will be furnished by the St. Louis Car Company. It is estimated the first plane will be ready for demonstration and sale in the course of 60 or 90 days.

Charles J. Authur, formerly sales engineer of the **A. R. Amos, Jr., Company**, Philadelphia, Pa., has been appointed representative of the **Wagner Electric Corporation**, St. Louis, Mo., with headquarters in Philadelphia.

Horace M. Wigney has been appointed manager of **Safety Refrigeration, Inc.**, with office at 75 West Street, New York. This is the subsidiary of **The Safety Car Heating & Lighting Co.**, which controls the use of Silica Gel for refrigeration in connection with transportation.

E. J. Phillips, who has represented the **Van Dorn Electric Tool Company**, Cleveland, Ohio, in the sale of its products at Detroit, is now located at San Francisco, Cal., having taken over that territory for the same company; he is succeeded in Michigan by **George Phillips**; **J. F. Spaulding** has been transferred to the Baltimore territory to take the place of **J. Beggs**, who has been transferred to the main office at Cleveland.

Hal F. Wright has been appointed assistant to general manager of sales, in addition to his other duties, of the **American Chain Company, Inc.**, and associate companies, with headquarters at Bridgeport, Conn.

C. R. Ahrens has been appointed eastern sales manager of the **Chicago Railway Signal & Supply Company**, with headquarters at 30 Church street, New York.

A. L. Datesman has been appointed sales representative for **Otis B. Duncan**, manufacturer's representative, 53 W. Jackson boulevard, Chicago.

Items of Personal Interest

D. W. Campbell, master mechanic on the Canadian National at Winnipeg, Man., has been transferred to the Kamloops division of the British Columbia district, with headquarters at Kamloops, B. C., to succeed **E. E. Austin**, who will retire.

The headquarters of **W. T. Fitzgerald**, master mechanic of the Nebraska-Colorado division of the Chicago, Rock Island & Pacific, have been moved from Goodland, Kan., to Fairbury, Neb.

Obituary

J. Snowden Bell died in Brooklyn, N. Y., November 27, 1928. Mr. Bell had been active in the field of mechanical engineering for about 70 years, and his was a name well known to readers of *Railway and Locomotive Engineering* to which he had been a contributing editor for many years. Mr. Bell was born July 11, 1843, in the city of Philadelphia. He was educated at the Central High School in that city and in the Polytechnic College.

In 1862 he entered the service of the Baltimore & Ohio Railroad as a draftsman under Thatcher Perkins. He left the railroad at the outbreak of the Civil War and in 1864 was appointed third assistant engineer of the Frigate Minnesota. When he left the navy in 1865 he re-entered the service of the B. &. O. as chief draftsman under Mr. Perkins, who at the time was Master of Machinery at the Mount Clare Shops, Baltimore, Md.

While with the Baltimore & Ohio he was engaged in making many of the drawings for the famous Perkins engines, which embraced 8-wheel passenger, 10-wheel passenger and 8-wheel connected freight engines, and also made many of the drawings for engines which were rebuilt at Mount Clare.

Late in 1865, Mr. Perkins was called to take the superintendency of the newly formed Pittsburgh Locomotive Works, and Mr. Bell went along as that work's first Chief Draftsman. Here he was employed first in laying out plans for the new shops and their equipment, afterwards working upon the drawings for their first locomotives. He left these works August 31, 1866.

In the 1870s, we find Mr. Bell back in Philadelphia, where he graduated from the University of Pennsylvania and received the degree of LL.B. in 1879, practicing under his own name as a mechanical engineer and patent attorney.

In 1883 Mr. Bell returned to Pittsburgh, where he engaged in patent law practice until 1909, when he came to New York to continue his practice in this city. During all these years his work in large measure was for the Westinghouse Air Brake Co., and the American Locomotive Co. A few years ago he became the Patent Attorney for the latter company, in whose service he remained actively down to the time of his death.

Mr. Bell was a strong advocate of the Wootten type of locomotive, and wrote many papers in relation to the type. He was also an authority upon locomotive boilers in general, feedwater heaters, superheaters, etc., and was the author of numerous papers upon these appliances.

He was also one of the foremost authorities on locomotive history and development and wrote and published many papers upon this subject.

Mr. Bell belonged to various societies, among which might be named the American Philosophical Society and the Franklin Institute of Philadelphia; and he was for long an active member of the Railway Master Mechanics Association and the Mechanical Section of the A. R. A., attending all their meetings, contributing many papers and serving on various committees. He will be greatly missed at future sessions of the A. R. A. He was also a member of the Engineers Club of New York.

In his legal practice, Mr. Bell was admitted to some twenty-three courts, among which may be mentioned: Admitted to the Philadelphia bar June 14, 1879; to the Supreme Court, State of Pennsylvania, May 8, 1882; to the United States Supreme Court, March 19, 1886.

In his passing the railroad world has lost one who was doubtless the last railroad mechanical engineer whose actual knowledge and experience reached from the days prior to the Civil War down to the present time. In his passing, the publishers of this magazine have lost not only a valuable contributor, but a lifelong friend and adviser. One whose life and work were an inspiration to all who had his acquaintance.

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