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New Capabilities in Railroad Testing

By GLENN A. REIFF, M '72

Senior Project Enginee:

High Speed Ground Test Cente:

Pueblo, Colorado

A short distance east of the Rockies, where incredible railroading accomplishments of blazing steel trails through mountain passes and operating trains over rugged grades in severe weather began a century or more ago, 50 square miles of Colorado prairieland have been set aside for a new U. S. Department of Transportation field center. While the challenges to improve today's ground transportation systems are different, they are no less imposing than those faced by the pioneering surveyors, track layers, engineers, and trainmen as they worked to conquer the mountains.

The High Speed Ground Test Center, HSGTC, is an essential part of a national effort to develop a more balanced transportation system and will offer new dimensions for rail-guided vehicle testing. Presently, the Federal Railroad Administration and the Urban Mass Transportation Administration are the principal participants at the Test Center. Managed by the Federal Railroad Administration, HSGTC will have test track and guideway complexes, laboratories, vehicles, and other facilities necessary to provide an advanced testing capability for railway, transit and other forms of ground transportation.

Many railroaders and others have indicated an interest in the Test Center. While some are expressing general interest and an understanding of the need, others are planning tests to be conducted at the Center. This article provides a general description of the Test Center itself and summarizes the ongoing test projects.

Over the years, many have contemplated needs for more comprehensive ground transportation test facilities. The American Railway Engineering Association and other professional associations have, of course, been deeply involved. But the genesis of the Test Center stems from the High Speed Ground Transportation Act of 1965. If higher speed vehicles were to be developed, dedicated facilities for testing would be required. Almost a hundred sites throughout the country were initially considered, and this field was then narrowed to a group of about ten. Each was evaluated against previously established criteria, and the area near Pueblo, Colo., was judged to be the best and selected in December 1969.

The evaluation criteria included such factors as:

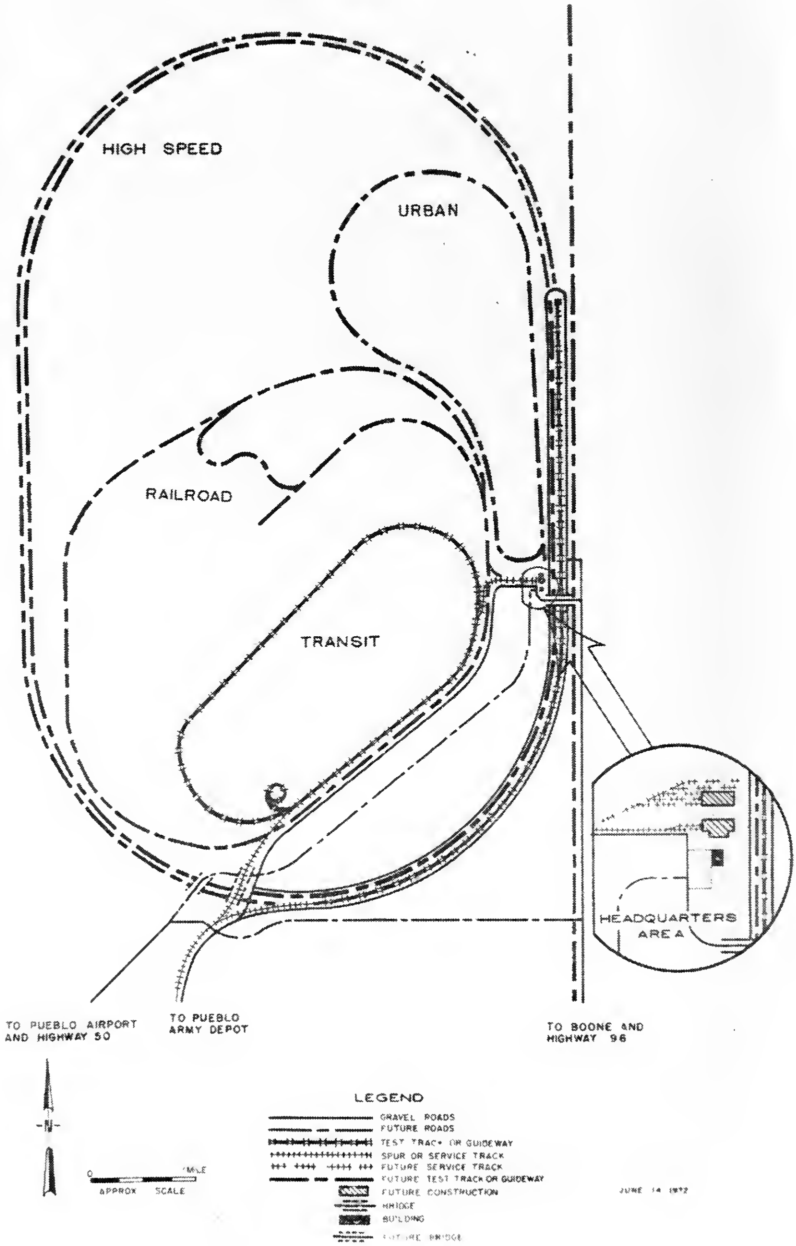
(1) Topography, geology, and site preparation costs
(2) Diverse climate
(3) Accessibility to highway, air, and railroad transportation
(4) Effect on local community
(5) Technical, industrial and local support

The area selected northeast of Pueblo is semiarid rangeland consisting of rolling plains, broken by normally dry arroyos; and generally treeless, covered mainly with sparse bunch grass, sagebrush, tumbleweeds and occasional cacti. While apparently completely dry, there are a few places where surface water exists continuously. Although barren in appearance, the fragile vegetation and wildlife—antelope, coyotes, snakes, prairie dogs, insects, birds and other animals—combine to provide a sensitive ecological balance.

HIGH SPEED GROUND TEST CENTER

U.S. DEPARTMENT OF TRANSPORTATION

PUEBLO, COLORADO



Geologic history recorded in the outcroppings of the area consists of only three major events. The earliest is submergence of the land and deposition of marine deposits under a broad, shallow Cretaceous sea. The second involves the uplift of the land, deposition of nonmarine deposits, and folding and faulting of the crust. The third includes the erosion of previously deposited sedimentary rocks, evolution of the modern drainage network, and deposition of the Quaternary surficial deposits.

At the time of selection, most of the land was owned by the State of Colorado with a small percentage privately held.

Elevations in the northeast part are about 5,300 ft, mean sea level, and in the southwest 4,830 ft. This is a drop of about 470 ft in almost 11 miles, giving an average grade of about 0.8 percent. But the topography of the site varies from gently sloping and slightly undulating terrain on the south and west sides to progressively more sharply rolling and hummocky sand hills to the north and east. Soil borings have shown that the area is predominately sand intermixed with clay. Some areas with clay soils exposed have been used as a source of embankment materials; but in the larger areas of wind-blown sand, stabilization has had to be provided. Test track route and grade designs have avoided cuts where possible to prevent disturbing natural vegetation and the sand binding it provides.

The selected area is about 10 miles north of the Arkansas River and 30 miles east of the Rockies, and the weather there is dominated by high elevations and the mountains. It is marked with large daily temperature variations, bright sunlight, and low humidity. The rigorous environment is particularly suited to transportation system testing. The following climatological data have been reported by the Weather Bureau Station at the Pueblo Memorial Airport, about 20 miles from the Center.

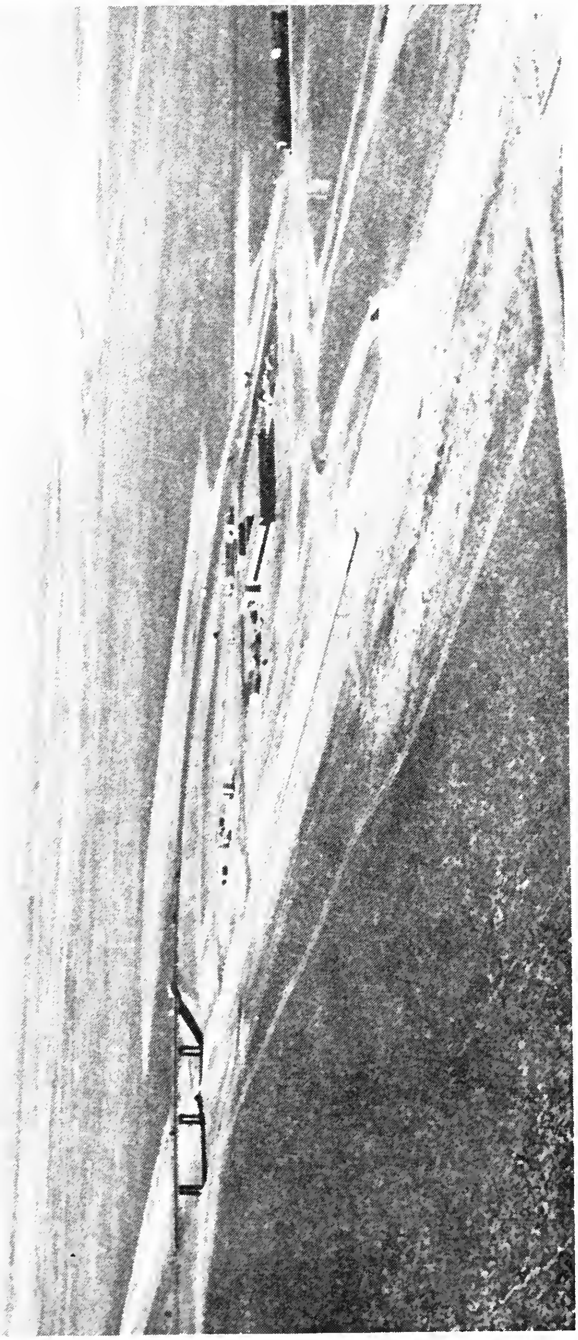
Mean diurnal temperature changes are about 30 deg F with extremes sometimes in excess of 60 deg.

The sun shines about 73 percent of the possible time creating a significant amount of radiant heat in metallic and other exposed surfaces. Averages of direct and diffuse solar radiation are about 650 Langleys in July, and 260 in January. This is typically some 25 to 75 percent more radiant energy at ground level from the sun than appears along the northeast coastal regions of the United States. During periods of little wind or convective currents, steel track temperatures as high as 135 and aluminum rail temperatures up to 120 deg have been reported at the Center during the summer.

Normal daily maximum ambient temperature in July, the warmest month, is about 92 deg F with extremes of 105 and 51 having been recorded. The probability of measurable precipitation in summer is one day out of four and in winter one out of eight. Summer rains usually occur in the form of afternoon thunderstorms. Dust storms are frequent during the spring months and create sand removal problems.

In January, the coldest month, normal daily maximum temperature is about 45 deg with extremes of 78 and —17 having been reported. Winter is comparatively mild because of the abundance of sunshine, with temperatures on most days reaching 50 degrees or higher. The temperature drops to 0 or below about eight times during the winter on the average. Cold spells are generally broken after a few days by Chinook winds, a warm, very dry, westerly wind.

Gravel access roads leading to the 30,000-acre site originate at the Pueblo Memorial Airport and from State Highway 96, one mile west of Boone, Colo. The headquarters area is almost 30 miles by road from downtown Pueblo and about



Aerial photograph of High Speed Ground Test Center.

60 miles from Colorado Springs. Air transportation connections are made at the airport through Frontier Airlines.

Four railroads serve Pueblo—the Denver & Rio Grande Western, Colorado & Southern, Missouri Pacific, and Atchison, Topeka and Santa Fe. Rail access to the Test Center is obtained from the Santa Fe/Missouri Pacific main line at North Avondale north through the Pueblo Army Depot to the Center. Most of the people working at the Center live in Pueblo, but some live as far away as Colorado Springs. Several are utilizing the academic resources of Southern Colorado State College in Pueblo.

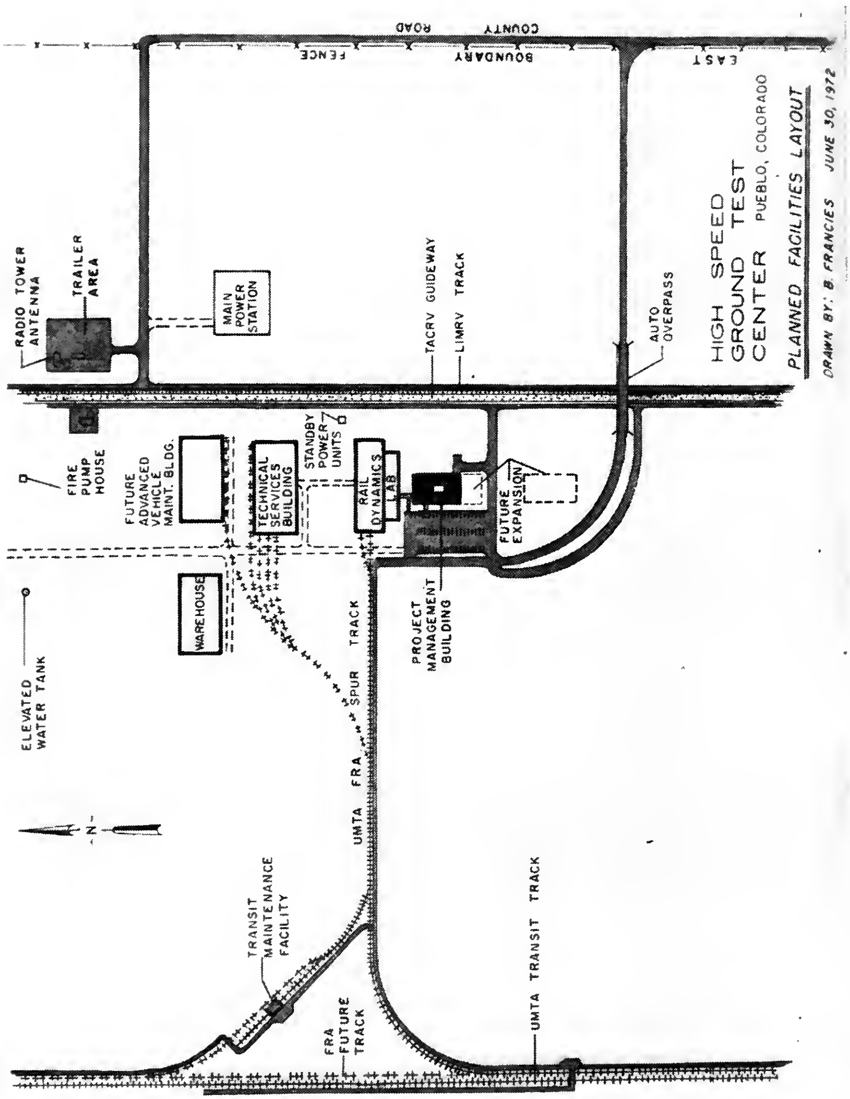
The HSGTC will serve ground transportation in the same way as wind tunnels and flight test ranges have provided development capabilities to aviation. There are many federally sponsored research laboratories, wind tunnels and flight test centers in our country today, all working to improve aeronautical or space flight. For example, NASA's Langley Research Center in Virginia, established in about 1916, has provided both theory and wind tunnel testing of supersonic shapes, short takeoff aircraft, and other aerodynamic configurations used by commercial aviation; and Edwards Flight Test Center, a 300,000-acre, highly instrumented test range located in the Mojave Desert of Southern California, has been the proving ground for many airplanes during the past quarter of a century. But, these kinds of development facilities have not existed for surface transport.

While the railroads, transit properties, their associations, suppliers and manufacturers have all conducted research and testing activities, track complexes completely dedicated to full-scale testing of different types of ground vehicles of various speeds and their guideways have not previously been available in one location. This capability, along with laboratories and simulators for probing many railway technical problems, are now in preparation at the High Speed Ground Test Center

Construction of a Dynamics Laboratory was started at the Test Center in July 1972. This laboratory, containing wheel/rail simulators, will be developed through several contracts. The first contract, for design, was awarded to Wyle Laboratories of Huntsville, Ala., during 1970. The contract award was termed by Secretary of Transportation John A. Volpe as "an attempt to enable railroad research to be performed with modern tools comparable to those used in advanced aerospace technology." The contract for the building itself is with Houston Construction/Wilkins Construction of Colorado; and subsequent contracts for such components as cranes, drive train, carriage assemblies and structures, wheel modules, and control equipment are in process.

The main laboratory testing machine has been designed to accommodate vehicles up to 180 ft in length and consists of a number of modules which can be assembled to match the axle spacings, wheel base and gage of railroad or transit equipment. Each wheel of a test specimen rests on a matching roller which can be moved to simulate track irregularities. Each roller is connected to a flywheel system which provides a sufficient inertia such that the wheel/rail interface condition simulates a moving vehicle on a stationary rail. They are currently designed to support axle loads of 80,000 lb. Curve radius of 100 ft minimum can be simulated.

All of the power and forcing systems, instrumentation and controls are designed for reorientation to perform dynamic, fatigue, or compliance tests on subsystems and components, such as wheels, brakes, and suspension systems. Hydraulic power for each single-axle test system has been divided into three systems, each having a different hydraulic flow and pressure requirement.


HIGH SPEED
GROUND TEST
CENTER PUEBLO, COLORADO
PLANNED FACILITIES LAYOUT
DRAWN BY: B. FRANCIES JUNE 30, 1972
COUNTY ROAD
EAST BOUNDARY FENCE
RADIO TOWER ANTENNA
TRAILER AREA
MAIN POWER STATION
TACRV GUIDEWAY
LIMRV TRACK
AUTO OVERPASS
FIRE PUMP HOUSE
FUTURE ADVANCED VEHICLE MAINT. BLDG.
TECHNICAL SERVICES BUILDING
STANDBY POWER UNITS
RAIL DYNAMICS LAB
FUTURE EXPANSION
PROJECT MANAGEMENT BUILDING
WAREHOUSE
ELEVATED WATER TANK
SPUR
UMTA FRA TRACK
N
TRANSIT MAINTENANCE FACILITY
FRA FUTURE TRACK
UMTA TRANSIT TRACK

When completed, this facility will provide a wide-range, highly flexible laboratory to support all phases of railroad and transit research at speeds up to almost 300 mph. This unique testing capability will provide an ability to control and measure many functions independently, with freedom to exceed normal conditions to the point of hazard, and independence from the operational constraints which prevail on revenue lines.

Railroad and transit test tracks of various configurations and an impact area are also being built for use in conjunction with the Dynamics Laboratory.

To date, a total of about 22 miles of track has been finished. This total includes 6.2 miles of specialized trackage with a 21-inch-high reaction rail installed in the middle, which is part of a linear induction motor, and a 9-mile transit track. The balance of the trackage consists of access spurs.

The Transit Test Track includes an electrified third rail, instrumented roadbed, both 119- and 100-lb rail, concrete and wooden ties, and both welded and bolted joints. It is planned that tight curves, or "screech loops," and alternate electrification configurations will be added to this transit complex later.

Approximately 20 miles of test track for more conventional railroad freight and passenger equipment are also being laid out. This facility will consist of a Main Loop and a Train Dynamics Track. The Main Loop will accept speeds up to 120 mph with some runs up to about 160 mph being possible with special rolling stock. Selfpowered commuter cars with speed capabilities above 80 mph can also be run on this test track. Wooden ties and 136-lb rail will be used in this track network. The Train Dynamics Track includes special sections tied into the Main Loop. Critical grades and curves, switching, humps and yard tracks are planned. Parts of this track will be roughened or smoothed as appropriate for dynamic vehicle tests. Track buckling experiments are also contemplated. Some destructive tests are expected, including derailment and collision work, grade crossing trials, and tank car accident investigations.

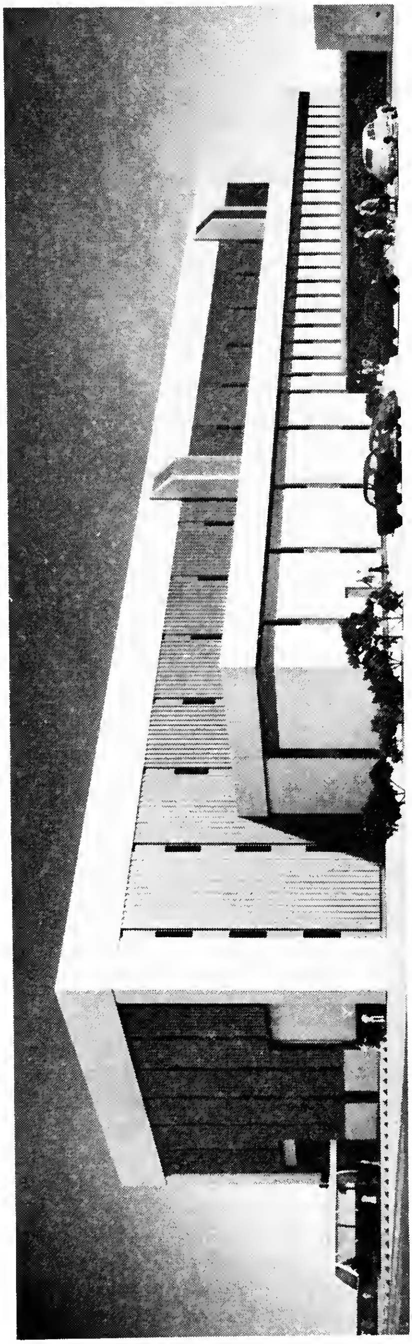
These two track complexes—transit and railroad—will provide the means for conducting many different kinds of safety, efficiency, human factor, traction, comfort, and other tests.

Additional construction, which has either been completed or is underway, includes a project management building, automobile overpass, service and access roads, concrete guideways for air cushion vehicles, a water system, and maintenance buildings.

This construction work has been contracted for by the Federal Highway Administration, Region 8 in Denver; the Federal Aviation Administration Regional Offices in Los Angeles and Denver; or the Federal Railroad Administration in Washington. Federal Railroad Administrator John W. Ingram said, "At the High Speed Ground Test Center at Pueblo we will undertake the dynamic testing of rail and transit vehicle suspensions and begin a study of wheel/rail interaction in order to make rail travel safer, faster, and to assure a smoother ride."

Basic site layout and master planning are provided by the Test Center and Demonstrations Division of the Office of Research, Development and Demonstrations, Federal Railroad Administration. A contract for maintenance and operation services at HSGTC was awarded to the Kentron Hawaii Ltd., Continental Division of LTV Aerospace Corporation, in June 1972.

Several Federal laws designed to improve surface transport have been passed within the last ten years, and some were designed to increase the research and development activities in ground transportation. As a result, many new or non-



Photograph of a model of the Dynamics Laboratory.

conventional ground vehicle concepts are being studied; and if they are brought to the prototype stage, we will expect to evaluate them at the Test Center. Dual mode machines, magnetically levitated vehicles, suspended vehicles, trams, intercity cars, and tube vehicles may all eventually be tested at the Center.

Those currently scheduled, however, are the Linear Induction Motor Research Vehicle (LIMRV); portable rail diagnostic equipment; State-of-the-Art Transit Cars (SOAC); a Tracked Air Cushion Research Vehicle (TACRV); an Urban Tracked Air Cushion Vehicle (UTACV); Advanced Concept Rapid Transit Cars (ACT); obstacle detectors; and power collectors. Intercity rail and advanced systems planning and testing are carried out by the Advanced Systems Division and Rail Systems Division of the Office of Research, Development and Demonstrations. Transit related planning and testing are carried out by the Urban Mass Transportation Administration's Office of Research, Development and Demonstrations in Washington and by its Rail Supporting Technology Systems Manager, the Transportation Systems Center (TSC) in Cambridge, Mass.

The Center's first test project is centered around the experimental LIMRV built by Garrett AiResearch in California and designed for speeds up to 250 mph. This particular vehicle can be operated either manned or by remote control, but it will never be placed into passenger service. It is a research vehicle to be used for developing the linear electric motor as an advanced form of propulsion. These motors will be nearly pollutant-free, very quiet, and contain almost no moving parts. In tests to date the LIMRV has been operated at speeds up to 187.9 mph.

Two New York R-42 subway cars are presently at the Center and are serving as test beds for developing instrumentation which will ultimately become part of a portable rail diagnostic laboratory. This instrumentation is under development by the Cambridge Transportation Systems Center. The objective is to develop a "suitcase" instrumentation system that can be installed aboard cars on different transit properties in order to measure track geometry, ride quality, safety, and other parameters.

The Vertol Division of Boeing in Pennsylvania has procured for the Urban Mass Transportation Administration two newly designed transit cars representative of the current state-of-the-art. Performance characteristics, such as speed, braking, acceleration, noise, and ride quality, of these SOAC cars will be evaluated at the Test Center prior to demonstrations in several cities throughout the country during 1973. The next generation of rapid transit cars, ACT-1, will also utilize the Test Center for extensive testing.

The TACRV, built by Grumman Aerospace in New York, was on display at Dulles Airport last May during TRANSPO 72. It was shipped from there to the Test Center and is now being prepared for tests. This type of vehicle floats on a thin cushion of air within a concrete trough or guideway. Initially, it will be levitated and propelled by turbofans, but within the year a backfitting program should be started to install an 8,000-hp linear induction motor which utilizes a reaction rail and should provide speeds up to about 300 mph. Lower speed tests are scheduled to start this coming winter, and by next summer the vehicle should be operating in its electrified configuration.

Another air cushion vehicle, called the UTACV, is to be provided by Rohr Industries of California. The design of this vehicle closely follows that of the French Aerotrain, and as such will be capable of speeds of about 150 mph. This is considered to represent the current state-of-the-art in air cushion vehicles. Evaluation tests on it are scheduled to start at the Center in early 1973.

As speeds are increased, obstacles in the path of ground vehicles will become an even more dangerous problem than they are today. Research on detectors has been underway for several years, and the first elements of an experimental system are scheduled to be installed at the Center next winter.

Many of the test vehicles utilize some form of electrical power as their basic source of energy, and the Dynamics Laboratory will be a heavy user of electrical power. These electrical loads are characterized by relatively large demands of short duration. By 1975, the Test Center may have a 20-megawatt demand with a load factor of only 17% and use a total energy of about 275×10^5 kilowatt-hours during the year. This power will be delivered at a nominal voltage of 115 kilovolts to the main substation from commercial sources. From the internal distribution system of the Test Center it will be modified to the form required by each vehicle. For example, the transit cars nominally utilize 600 volts direct current, and the 300-mph wayside power pickup system under development for the TACRV requires 60 Hertz, 3-Phase at 8.250 kilovolts.

These research, development, test and evaluation (RDT&E) projects are sponsored by the Federal Railroad and Urban Mass Transportation Administrations. With this participation, four of the seven operating, or modal, administrations of the U. S. Department of Transportation are involved with work at the Test Center.

Additional support has been provided by the Pueblo Army Depot; NASA's Langley Research Center; Jet Propulsion Laboratory; Naval Air Engineering Center; National Ocean Survey, a part of the Department of Commerce's National Oceanic and Atmospheric Administration; Army's Corps of Engineers; Soil Conservation Service, Department of Agriculture; and the Pueblo community.

There are indications of growing national and international interest in the HSGTC. In addition to many business and professional groups from the United States that have visited the Test Center, there have been visitors from Canada, Mexico, Nicaragua, England, France, West Germany, Japan, Switzerland, Italy, and Sweden.

As more construction is completed and activities expand, it is expected that test projects may be established by private industry and their associations, both foreign and domestic, or by other governments.

Over 150 years ago, during 1817, John C. Calhoun stated: "We are greatly and rapidly—I was about to say fearfully—growing. This is our pride and our danger; our weakness and our strength . . . let us, then, bind the Republic together with a perfect system of roads and canals." Today, based upon population growth projections, it has been estimated that the country will have to provide in the next two decades as much transportation capacity as has been gradually built up since our very beginning as a nation two centuries ago.

So, some of our problems are not new, but we do have new ways of approaching and solving them. Our ability to send spacecraft to the planets or men to the moon was created by blending many technologies into what was, ten years ago, called a new space technology. At HSGTC, a different blending of many technologies—railroading, transit, aeronautics, roadway, materials, electronics, automation, etc.—will be sought in order to continue making advances in existing railroad or transit equipment; and, at the same time, to provide the means for testing new concepts in ground transportation vehicles or subsystems.

Just as railroading pioneers opened new vistas on the other side of the mountains a hundred years ago, the High Speed Ground Test Center will become instrumental in a renaissance of ground transportation.

Advance Report of Committee 16—Economics of Plant, Equipment and Operations

Report on Assignment 1

Study Optimum Length, Speed and Weight of Freight Trains Under Varying Traffic and Competitive and Operating Conditions Relating to: (a) Balanced Trains, (b) Long Train Operation, and (c) Short Train Operation

J. C. MARTIN *(chairman, subcommittee)*, W. L. PAUL *(vice chairman, subcommittee)*, B. G. GALLACHER, H. N. LADEN, A. S. LANG, T. J. MATTLE, V. J. ROGGEVEEN, A. L. SAMS, L. K. SILLCOX, T. H. SJOSTRAND, J. J. STARK, JR., M. J. SHEARER, JR., A. J. STROBEL, F. WASCOE, J. R. WILMOT, T. D. WOFFORD, JR.

Your committee submits the following report as information.

The study of optimum train lengths indicates that there is no one optimum length of train that will meet all requirements under all conditions. Generally, within reasonable limits, railroad costs tend to favor long, slow trains while service requirements and competition favor short, fast and frequent trains. The third category, balanced trains, comprises those trains where power, crew, etc., are balanced so that round trip movements, such as in the case of a unit train operation, are governed by other considerations often outside the control of the railway company.

As train length increases within physical limits, crew cost per unit of freight hauled decreases. The advantage of running long trains is, of course, that one runs fewer of them, with savings in crews and cabooses. In addition, the running of long trains can improve track capacity. Sidings are longer but fewer. There is less need for additional main tracks. Signals can be spaced farther apart. There is less train delay caused by congestion. The result, therefore, is a lower investment in plant.

On the other hand, certain other factors tend to increase costs. As the length of train and therefore the tonnage increases, the difficulty of train handling increases, resulting in a higher "break-in-two" potential with consequent increased delay. By running longer trains and thus fewer trains, cars will be subject to additional terminal delay awaiting connections which will thus increase the car cycle. The resulting increase in car cycle will increase equipment investment costs. To avoid yard congestion, longer departure and receiving tracks must be provded if the long train is to be handled as expeditiously as possible without tying up leads and switch engines, because of the inability to yard on a single track.

However, competitive conditions may dictate that a fast train service must be provided if a certain traffic is to be maintained by the railway. Under these conditions, it may be possible to justify running short trains when the resulting higher speed of a short train with minimum interference and switching produces a shorter turnaround time and higher revenues. Thus, the shorter train minimizes the effects of increased crew costs through savings in equipment costs. Also, in many cases, the customer pays a premium for this type of service.

Balanced trains require large volumes and steady rate of movement. A typical unit train operation may be governed further by such limitations as the rate of loading at the initial terminal, the rate of unloading at the final terminal, and the amount of tonnage to be handled, usually on a guaranteed annual basis.

It is feasible to describe in detail the various plus and minus effects on expenses to be anticipated from changes in train length and to evaluate them when considering any specific case. A simple definition of an optimum train length is that length which maximizes profit.

These items are described as follows:

1. EQUIPMENT LIMITATIONS

1.1 Number of Powered Axles

It is usual to limit the number of units on a train by specifying the number of powered axles that can be used. This is a function of the coupler strength of the equipment. It is not uncommon for couplers or knuckles to fail when drawbar pulls of more than 260,000 lb are applied, particularly at low speeds. This occurs usually in the older types of equipment which are normally found on regular trains, and for this reason the number of units or powered axles are usually governed by the drawbar pull being limited to about 250,000 lb. On unit trains which have been supplied with the newer type of equipment having high-strength couplers the drawbar pull can be increased to 300,000–400,000 lb.

1.2 MU'd Diesel Units

1.2.1 Reverse Movements

As an extension to item 1.1, special instructions require extreme care in making reverse movements whenever MU'd units are operated and that slack be streched before such movements are made. This limitation reflects the danger from high starting resistance in reverse movements, causing couplers to angle slightly resulting in high lateral forces against the rail head which in turn will result in overturned rails.

1.2.2 Braking

There is strong evidence that heavy dynamic brake applications on heavy trains having relatively high dynamic braking capacity and when certain types of cars and track conditions exist may contribute to damage of the track structure and result in derailments.

1.3 Air Brake Operation

With long trains, the interval is longer between the time the application is made at the locomotive and the time that the brakes apply at the rear end of the train, which increases the total stopping distance of the train. With long trains, there is also a greater tendency to slack action when a heavy brake application is made due to all of the brakes not applying at the same time. It is therefore usually necessary to limit the speed of these long, heavy trains because of greatly increased stopping distance and inadequate signal spacing or flagging protection.

Long trains can cause another problem on heavy mountain grades. After a train is stopped by a heavy service application and is then ready to proceed, the engine-man must first hold the train with the independent air while he recharges the trainline in order to release the train brakes. With very long trains, it is possible for the locomotive to have insufficient weight and adhesion for the independent brakes to hold the train while the trainline is being recharged.

In cold weather, it is often difficult to get the required pressure or gradient as required by authority because of leakage at joints and couplings caused by the shrinkage of metal or plastic connections. In these instances, it is often necessary to set out cars, reducing train length until the train can meet the terminal brake test requirements.

1.4 Slack Action as a Result of Profile

Any change of grade exceeding 0.5% can be critical due to the impact forces set up between cars through the coupler by the induced change of speed. Long trains result in increased slack action which is most noticeable in heavy sags and is especially significant in track having an undulating profile even though the grades are not severe. As a result, it is usually necessary to impose speed restrictions at sags and crests on undulating track, lengthening grid time and reducing effective plant capacity.

1.5 Car Equipment Limitations

Car equipment can be a limitation to long trains, particularly with regard to buffing forces and drawbar strength. In addition, certain equipment consisting of light, long cars such as tri-levels can be a potential hazard when placed near the head end of a long, heavy train on curved territory. This would cause the wheels to lift and ride over the top of the rail.

1.6 Number of Trailing Axles

The number of trailing axles may be assumed to be directly proportional to the number of cars, which in turn can be identified with journal friction (varying with temperature) and which in turn relate directly to train resistance. As train resistance increases, drawbar pull increases and therefore the power limitations as set out in 1.1 will govern the length of train through allowable drawbar pull.

2. OPERATING AND PLANT LIMITATIONS

2.1 Terminal Yards

2.1.1 Inbound Inspection

Car inspection staffs at terminals are usually fixed at a maximum number to handle normal trains within a reasonable period of time. Consequently, if longer than normal trains arrive in the yard, extra time must be allowed to complete the inspection before the train can be released for switching or humping, thus adding to the total trip time.

2.1.2 Charging Trainline

Charging trainlines is done in one of three ways:

1. By ground air lines
2. By the road engine crew after reporting for duty
3. By a yard engine

The latter two methods are used where ground lines are not available. Where ground lines are available, the cost of charging the train has no bearing on its length as the economics of charging a long train are negligible over the alternative of charging several smaller ones.

When the use of a road or a yard engine is required, the cost of terminal time to the road crew must be weighed against lost switching service of the yard crew. Generally the practice is to charge shorter trains with road crews and longer trains with yard crews. The use of yard crews will eliminate further delays involving terminal air tests as they then can be made prior to road crews reporting for duty.

2.1.3 Terminal Air Test

The relative importance of the terminal air test is dependent on the method of charging the train and when the air test is made. Where ground lines are used, a crew of car inspectors can check one long train just as effectively as several shorter ones. If the road crew charges their own train, time must be allotted to make the terminal air test, and the additional labor charges must be weighed against lost moving time.

2.1.4 Doubling In or Out

Doubling in or out of a terminal or a yard would appear to be a most important factor in determining optimum train length. In trains of great length, economics decree that the trainline be charged and the test made prior to the road crew reporting for duty. When this is done, the time consumed in doubling, making a road test and departing is more than justified in comparison with the cost of another crew. If, however, it is not possible to charge the train and make a preliminary air test, terminal time crew cost could appreciably increase and be a factor in determining optimum train length.

In determining the cost of such doubling, consideration would need to be given to:

2.1.4.1 Additional wage expense of the road crew if the particular work is performed by it. This expense may be in the nature of additional time, arbitrary allowances, or special terminal switching allowances or for terminal delays.

2.1.4.2 Any delays to yard or terminal switching by other crews that may result in extra train or engine expense would need to be taken into account as well.

2.1.4.3 The net income effect of these costs would then have to be weighed against the cost of eliminating such doubling over by possibly lengthening the receiving or departure tracks where it is physically possible to do so. These costs would include the cost of maintaining the additional trackage and carrying charges related to construction expense.

2.1.5 Yard Switching

Yard switching may be adversely affected by long trains blocking leads through the necessity of having to double into or out of receiving and departure tracks. This may result in additional yard crew switching expense if done outside of regular crew time or if arbitraries are allowed.

If the delay time involved in such additional switching is considered to be a seriously adverse factor from the freight service standpoint, an economic evaluation must be made on the possible loss in net freight revenue if business were lost thereby versus the possible gain in net freight revenue that might be developed through improvement in overall haul time and reduction in train expense.

2.2 Intermediate Yards

In addition to those elements which are similar for the terminal yards as mentioned above, intermediate yards may be further affected by the following:

2.2.1 Fueling

For a given flow of traffic between two points the longer the train length operated, the longer will be the fueling time or the higher will be the capital cost of fueling equipment. In other words, if there is a fueling facility capable of fueling four diesel units at one time, then a train with eight diesel units will require twice as long to fuel plus the time required to move the train to the second spot. To be fueled in the same time as the train with four diesel units, it will require twice as much rack and pumping capacity.

Another variation that can be considered is the possibility of truck fueling, and consideration would have to be given here for the cost of providing sufficient truck capacity to perform the work within the time allotted.

2.2.2 Pull-by Inspection

A train of twice the length of another train will require twice as much time to be pulled by a given point for inspection or alternatively could be inspected in the same time as the shorter train by having twice the inspection forces stationed at two points. The over-the-road time of the long train will thus be adversely affected by the longer pull-by inspection time or inspection costs would be increased if it were required to have the train pass through the intermediate terminal within the shorter period of time.

2.3 Effects of Blocking

2.3.1 At Intermediate Terminals

When a train picks up cars at an intermediate terminal, the pick-ups must either be picked up "out of block" as a unit to be dropped at a subsequent terminal for proper blocking for a later train or may be cut into the proper blocks in the first train. The former option causes the least delay to traffic already in the train; the latter option delays traffic already in the train but causes less delay to the traffic picked up. Where traffic is cut into proper blocks, the longer the train the more difficult it is to switch the train. Switching time can be reduced by increasing switching facilities and using more than one switch unit.

At intermediate yards, the dollar vs. time trade-off is more difficult due to generally smaller staffs with resultant greater proportional requirements for plant change to minimize conflicting train and yard delays.

2.3.2 Bridge and Car Location Restrictions

On second-class main lines there may exist a weight restriction over some specific bridges. On these bridges, care must be taken not to handle two or more heavy cars next to each other. It is recommended that these heavy cars be separated by one or more light cars.

When possible, because of dynamic forces that occur on heavy grades, some types of cars such as long, light cars should not be placed immediately behind the locomotives. In addition, tri-level cars should not be placed next to open top loads such as sand, coal, sulphur, etc.

The longer the trains are, the more difficult it will be to perform the additional switching created by these restrictions.

2.4 Over-the-Road

2.4.1 Increased Grid Time and Frequency of Overtakes

Increased train lengths increase the stopping distances, thus slower maximum speeds are often required for longer trains. Also, it takes longer to traverse speed restricted areas with longer trains than with shorter trains since the total length of a speed restriction area is usually the length of restricted track plus the length of the train. Grade crossings are sometimes exceptions, where the restriction is the length of the restricted track only.

The fact that the above factors increase the grid time or over-the-road time for longer trains increases the likelihood of other trains overtaking the long train. Increasing the frequency of overtakes will further increase the amount of delay to a long train on single track. However, most delays will be offset when on double track by using reverse running.

2.4.2 Reduced Meets

The effect of running longer trains should normally be to run fewer trains. Therefore, this will result in fewer meets on line and will tend to offset to some degree the increased grid time mentiond above. In addition, the rate of reduction in meets will be higher than the rate of reduction in trains.

2.4.3 Conflict With Other Trains

As stated above, the effect of running long trains is generally to run slower trains and thus the relationship and conflict with trains of higher speed and priority worsens as the differential in speed becomes greater.

2.4.4 Number and Length of Sidings

The number and length of sidings fall into a group of semi-variable costs which are those which occur only when the increase in mileage or density of traffic advances sufficiently to require the additional facilities. If longer and therefore fewer trains are run, then theoretically fewer and longer sidings are required, which should reflect a saving in some costs for turnouts and other costs connected with providing signal protection for each siding. However, taking into account items 1, 2, and 3 above, it may be that because the trains are slower, the number of sidings may not reduce proportionally to the number of trains and, therefore, the savings in plant will not be proportional.

2.4.5 Blocking of Crossings

Any train stops brought about due to signal indications should be made, as far as practicable, so as to avoid the blocking of road crossings, since a prevalance of such undesirable blockage of important and dense highway routes results in demands for grade separation. The longer the train, the more likely will be the possibility of affecting road crossings and railroad crossings at grade.

2.4.6 Damage to Equipment and Lading

Damage to equipment and lading results in a large measure from the interchange of inertia effects caused by different parts of a train being on various gradients with some portions stretched and others bunched and then balancing upon reaching level track. It requires great skill on the part of the engine crew to avoid run-in and run-out of slack, which cause break-in-two's on long trains since the motive power can well represent a good percentage of the weight of the entire tonnage it hauls.

2.4.7 Crew Costs—Constructive Allowances, Back Haul

Crew costs may be based on a certain maximum length of train or number of diesel units operated. Constructive allowances are provided for in operating above these limits and would have to be taken into account in determining costs vs. savings of long trains.

Crews and power available at an away terminal can be deadheaded home or used to haul a train. The cost of each alternative and the variables connected with each would have to be evaluated to determine optimum train length.

2.4.8 Effect of Grades

Trains of a given tonnage should operate intact between major terminals. An intermediate breaking up of trains to overcome heavy grades is a time-wasteful and costly process. It is equally undesirable to operate a locomotive over most of the line with tonnage significantly below its hauling capacity for that territory merely to enable it to haul the train non-stop over an excessively steep grade. When a reasonable balance cannot be reached between the ruling grade and the remainder of the line, it has been found more economical to select a new and lower ruling grade.

2.5 Track Limitations

2.5.1 Maintenance

The operation of fewer long trains to move a given quantity of traffic increases the time available for maintenance and the utilization of maintenance forces and equipment during scheduled work hours.

2.5.2 Track-Train Dynamics

The dynamic forces involved with train operation are not thoroughly understood. It is known that train length is one of the factors affecting these forces. This subject is presently under investigation by individual railroads and the AAR.

3. MISCELLANEOUS CONSIDERATIONS

3.1 Car Cycle

The effect of operating longer trains is usually to increase the car cycle. This is caused by the long train running at generally lower speed with resultant increase in the number of meets and overtakes, terminal and intermediate yard delays, and the fact that since longer trains are run, fewer trains operate, which can result in cars waiting in terminal yard tracks for connections which have become less frequent. Thus the carrying charges on an increased fleet should be considered as a result of the increased car cycle due to running longer and therefore fewer trains.

3.2 Customer Service

Customer service covers frequency of service to both consignee and consignor. This element breaks down into two categories: customers whose product has a high time value (that is, manufactured products or perishables) and for whom frequency is of first importance, and those whose product has a lower time value (that is, raw materials) and to whom frequency is not primordial. It should be borne in mind that length and frequency are inverse variables and that both enter into the economics of the matter for the railroad. The customer who is concerned (one whose product has a high time value) will be interested only in frequency and not in train length per se, assuming that lengths are stopped at a maximum limit before undesirable effects such as damage to lading from excessive slack action occur.

Custom-tailored services and guaranteed levels of performance would appear to become more difficult to design and achieve as trains become appreciably longer unless heavy reserve time is built into schedules.

3.3 Customer Plant

Limitations of plant at origin and/or destination can create extra railway costs if switching and transferring results from operation of trains exceeding the length acceptable for current handling by the customer. This is particularly true of unit trains.

3.4 Effect on Other Traffic

The effect on other traffic covers connections, although they may involve the same traffic on other sections of the same railroad or on other railroads. If we have a district where the physical and traffic characteristics would allow the operation of only one train per day westbound and if at the west end most of the traffic is turned over to another district or railroad, the optimum train length may be quite different if the other district or railroad also operates only one westbound train per day than if it operates four trains spaced throughout the day.

Longer trains, as has been mentioned previously, usually mean fewer trains and in many instances, it may be that only one train per day will be operated from one terminal to another specific terminal. Thus cars arriving at a terminal shortly after the train has left this terminal may actually stand in the yard for 24 hours before moving on toward their ultimate destination. If the long train is arriving at a terminal where it must be broken up into many blocks for departure on several trains, the additional switching time required for the long train may result in some cars missing their connections.

In extreme cases of long trains operated on schedules whose cycle exceeds a multiple of 24 hours, high priority trains will be adversely affected unless virtually all passing tracks otherwise required are maintained and lengthened.

3.5 Equipment Investment

As mentioned in 3.1 above, the effect of running longer and fewer trains will be normally to increase the number of cars required by the railway. Therefore, this additional cost must be taken into account when considering the benefits of running longer trains. This feature can quite easily be calculated in the case of unit or balanced train operation.

3.6 Motive Power Concentration and Cycling

Most railroads operate a motive power distribution control center in order to control the distribution of motive power on the various trains and thus maximize the use of the diesel power fleet. One possible effect of the operation of long trains will be the concentration of power on these trains and the result on the flow cycle if such long trains are operated on a sporadic basis. It may thus be necessary to operate trains in the reverse direction with an excess of power in order to return this power to a terminal where the power is required.

3.7 Operating Costs

The operating costs of long trains vs. short trains must take into account the obvious savings such as reduced number of crews and cabooses as against the increased cost of terminal delay, switching, over-the-road time as well as the effect of equipment and plant investment in the long-term outlook.

4. USE OF SLAVE POWER, AIR BRAKE REPEATER CARS AND HELPERS

Most of the previous remarks refer generally to normal train operation and, to some extent, some of these can be modified by the use of slave power, air brake repeater car and helper. It must be said that the use of slave power and air brake repeater cars is far from being universally accepted and that a good portion of their technology remains to be developed.

4.1 Remote Control (Slave)

4.1.1 Equipment Limitations

4.1.1.1 As mentioned above, the length of the train operated in the normal manner is governed by the allowable drawbar pull at the head end. By use of slave power, it is possible to lengthen trains made up of older equipment through the introduction of slave power which in effect creates a number of short trains joined together. Thus, if slack action can be kept under control on undulating track through the operation of slave power, the combined effect of slack action, coupler limitations and the number of powered axles may be reduced.

4.1.1.2 Slack action may be increased at some points in the train where slave power is used. Train dynamics are not well understood, but experience has indicated severe slack action at higher speeds and at certain locations in longer trains. The problem is compounded by cars having various ages, coupler strengths and being of different lengths.

4.1.1.3 Stopping distances can be decreased through use of slave power since a mid-train slave unit will release brake-pipe pressure simultaneously with the lead unit. Thus brakes will apply more quickly throughout the train and allow higher speeds.

4.1.2 Terminal Yards

Slave units must be cut out of trains on arrival to avoid adverse effects of utilization. This may have the effect of being equivalent to two doubles per inbound train and requires at least one hostler per shift or equivalent lost yard engine time for movement of the slave unit to the shop track. There appears to be no effect on outgoing trains if the same hostler can deliver the power to the train before doubling.

However, it must be realized that the effects of operating these abnormally long trains into terminal yards will probably be even more severe than the problems mentioned under items 2.1.4 and 2.1.5.

4.1.3 Intermediate Yards

The effect of operating slave trains through intermediate yards will be to effectively shut down conventional yards during their fueling and pullby inspection periods because of both their total overall length and the time required to move the train ahead in sections to the fueling station for each set of slave units. Alternatively, trucks of adequate tank capacity can be used, involving about the same time but would probably require lateral extension of the yard by one track per roadway provided for them.

4.1.4 Over-The-Road

Other considerations in the operation of slave power are:

4.1.4.1 The problems of controlling slave units in mountainous territory, especially where there are numerous tunnels, generally requires additional radio antenna installation to avoid losing contact with the slave units in the rear of the train.

4.1.4.2 Failure of slave units can be critical. All alarms and reset functions must be controlled from the lead unit to avoid enroute delay, both to the train on which the failure occurs and to other trains. The loss of contact with the slave unit or the failure of the slave unit in a heavy grade territory could cause the train to stall and require a very time-consuming doubling of the grade.

4.1.4.3 On extremely long trains, effective crew responsibility for checking the entire train is questionable. It will be necessary to consider whether existing planned density of hot box detectors and dragging equipment detectors is adequate where longer trains are operated and whether other installations are necessary.

4.1.4.4 *Service Considerations*

Slave power does not appear to influence these elements other than as secondary results if equipment and operating limitations are eased.

4.1.4.4.1 Effective unit train operation can be enhanced if slave power is used to minimize the spread of speed and thus conflict between relatively conventional length tonnage bulk trains vs. higher priority trains.

4.1.4.4.2 Where traffic characteristics permit trains compatible with existing sidings and yard tracks, a two-customer unit train involving an intermediate lift and/or set-off should lead to optimum power utilization, reduction of time for air tests and virtual main tracking of a tailor-made train.

4.2 Air Brake Repeater Car

The addition of an air brake repeater car within the train will not permit an increase in the number of cars in the train. This is explained by the fact that the length of the trains is governed by the allowable drawbar pull at the head end with or without air brake repeater car.

The true advantages of the air brake repeater car are:

—Faster charging of train line
—Improvement of train handling through faster brake application and release
—Shorter braking distances through faster brake application
—Help to maintain summer train length in cold weather

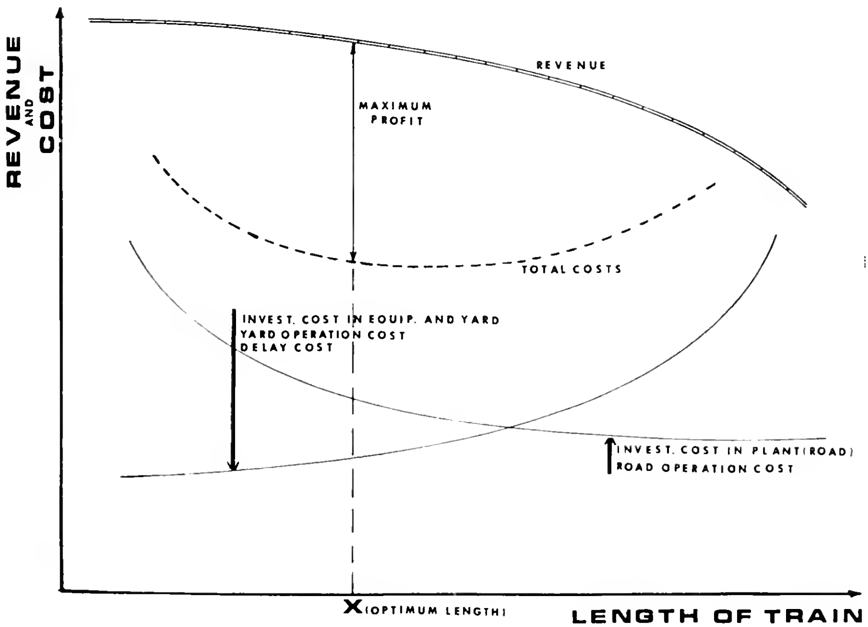
Disadvantages are also associated with this equipment:

—Extra piece of equipment to maintain
—Extra switching involved
—Fueling enroute of the repeater car
—Switching out of repeater car at hump yards

4.3 Helper Service

The use of helper service is not desirable unless it cannot be avoided. The simplest helper grade operation is that of a locomotive spotted in a pocket track at the foot of the helper grade. Passing sidings or even an entire second main may be necessary to carry the helper in returning or to avoid delay to through movement. Excessive delays occur when helpers must be cut into the middle of trains. Consideration must be given to the maintenance problems where helper service is located at remote points.

From the items mentioned above, it should be possible to estimate in dollars and cents the costs and benefits of operating different lengths of trains and thereby



arrive at an optimum train length for a particular movement. The real objective of a railroad should not be to minimize costs but rather to maximize profit. Longer trains work against maximizing profit in that they tend to reduce the quality of service and increase shippers' total distribution costs. The traditional bias toward longer trains may tend to cause railroads to minimize costs and at the same time reduce service quality. The latter in effect reduces revenue through either lower prices to retain a given amount of traffic or less traffic at the same price.

The figure on page 21 and simple example below show the relationship between the length of train and costs, and revenue and profit.

Simple Example of the Effect of Several Factors on the Relationship of Number of Trains to Profit

Assumptions:

1. A railroad receiving 110 cars per day at Point A for hauling 500 miles to Point B.

2. Fifty cars are available for train movement from Point A at 10:00 each day; the other 60 are available by 22:00.

3. Revenue per car averages $200 for the haul.

4. Total revenue won't change if cars are delayed.

5. Crew wages and fringe benefits are $1,500 per train run, regardless of length of train, weight of locomotive, time on road, or initial or final terminal delays.

6. If more than one train per day is operated, additional passing sidings will cost $100 per additional train per day.

7. The average cost of a car per day is $5.

8. Locomotive operating and maintenance costs, car maintenance costs, lading damage, insurance, and various other costs will not vary with train length for this example.

Operating Alternatives:

1. Operate one 50-car train daily leaving Point A at 10:00, and a 60-car train daily leaving Point A at 22:00.

2. Operate one 110-car train daily leaving Point A at 22:00.

Economics:

Only factors that change with the number of trains operated will be considered.

Alternative (1):

Train No. 1:	Revenue: 50 cars @ $200		$10,000
	Costs: Crew	$1,500	
Train No. 2:	Revenue: 60 cars @ $200		12,000
	Costs: Crew	1,500	
	Additional sidings	100	
	Total Revenue:		$22,000
	Total Cost		3,100
	Net Contribution		$18,900

Alternative (2):

One train:	Revenue: 110 cars @ $200		$22,000
	Costs: Crew	$1,500	
	Cars (Holding the first 50 cars an extra 12 hours will cause an effective 24-hour delay at the reeciving end): 50 cars @ $5.00	250	
	Total Revenue:		$22,000
	Total Cost		1,750
	Net Contribution		$20,250

Obviously, Alternative (2) is better since the contribution to profit will be greater if the first 50 cars are held an extra 12 hours from 10:00 to 22:00 in order to run one train. However, this causes an effective 24-hour delay to receivers who can only unload cars during certain hours at Point B.

Suppose Assumption (4) above is incorrect, and receivers divert 20 cars of traffic per day to another railroad or a truck line for faster service. Then Alternative (2) would result in the following:

Revenue:	90 cars @ $200		$18,000
Costs:	Crew	$1,500	
	Cars: 30 delayed @ $5	150	
	Total Revenue		$18,000
	Total Cost		1,650
	Net Contribution		$16,350

Now, Alternative (1) is better since the contribution to profit will be greater if two trains per day are operated. This is true even though the costs for Alternative (1) are greater than for Alternative (2).

Note in the above example that only the costs that vary with the number of trains operated have been calculated. The net contribution shown in each case is not net profit, since there are a number of other costs such as for fuel, clerical services, locomotives, etc., which would have to be deducted from net contributions to determine profits. However, the latter costs were assumed to be constant as noted in Assumption (8).

Many of the costs ignored above probably vary to some degree with the number and lengths of trains operated. These have been ignored to keep this example simple and to emphasize the often overlooked effect of service on revenues, which effect often can have a greater impact on profit than costs.

The example can be made much more complicated by adding more stations, trains, etc. The determination of optimum operations is extremely complex in real life, but is worth resolving for maximum profit and maximum efficiency to the economy as a whole.

Advance Report of Committee 14—Yards and Terminals

Report on Assignment 4

Urban Mass Transportation Terminals

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Your committee submits the following report on Urban Mass Transportation as information and recommends the subject be discontinued. The assignment concerned yards for car storage, stations and terminals, vehicular parking at stations, and rail access to airports. The report gives material that supplements the data found in the AREA *Manual* in Chapter 6—Buildings (Part 20 "Stations" and Part 25 "Shops") and to pages 14–2–1 to 14–2–19 specifically covering terminals, their design, equipment, and services. It also covers the factors to be considered when adapting the above references to present design standards.

A. INTRODUCTION

The four parts of the subcommittee's charge are difficult to isolate from the overall subject of mass transit. Discussing them in the abstract may result in an ideal for each aspect, but they must relate to the whole system, and their individual features are generally governed by the particular nature of the overall system. A true mass transit system will operate on an exclusive right-of-way and is not subject to the usual accidents, congestion, and other events that affect street traffic. A single such line has a capacity equal to 20 freeway lanes and can easily carry 40,000 persons an hour in a right-of-way width equal to a two-lane street. The nature of the actual system, therefore, greatly affects the character of the supporting systems.

The planners in the urban mass-transit area now have a very broad field to cover in integrating a system into a city complex. They must consider esthetics, land values, market analyses, noise control, social impact, transit operations, and visual and air pollution, to name a few areas. With careful control of development around stations, older communities can be rejuvenated and new business activities established.

Mass rail transit has declined significantly in the last three decades, however, and much needs to be done by way of innovations to make it more attractive. People will use it when it is convenient, saves time, and is reasonable in cost, and they will drive their own cars when it is not. Technical improvements in fare collection, rail car design, terminal design, train control, and other system components are already available. The Toronto area "GO" system is an example of this. It is specifically designed to attract automobile-users, and operates on a $2-million subsidy which is viewed as being vastly cheaper than building the highways that would be required to move the same people by car. The fare revenues, however, are generally expected to meet the operating and maintenance costs. Some form of subsidy, therefore, seems necessary for successful rapid-transit operations unless equal ingenuity is expended in revising the structure of the organizations operating the systems.

B. PASSENGER CAR SERVICE AND STORAGE YARDS

This report supplements the material on page 14–2–13, Part E, "Coach Yards" in the AREA *Manual*.

1. Service Yards

The number of trains to be terminal-inspected, the number for running repairs and servicing, the train lengths, and the layover time-schedules are the factors to be considered in designing these yards.

The car-washing facilities should be placed so this function can be done while the cars are moving between the station and the service yard and before the cars reach the inspection pits. The latter should be located to avoid delaying the trains as well as reducing switching operations. Some facilities have full-train-length pits.

All service tracks should be uniformly spaced on at least 20-ft centers and have service platforms between them. This will provide adequate side-clearance for the service vehicles and for supports for overhead lines and service outlets. Further, the area should be lighted for 24-hour operations, and the facilities should be equipped to completely service the cars and should include air, electrical, steam, and water outlets. Related facilities should include buildings for offices, locker and washrooms, repair shops, storehouses, and fire protection, as well as a refuse-disposal system.

2. Storage Yards

These yards should be on a level or nearly level gradient, and the tracks should be on a minimum of 14-ft centers or as required by state regulatory agencies.

C. STATIONS AND TERMINALS

Stations and terminals are designed to permit large numbers of people to rapidly transfer between travel modes in the most convenient and direct manner. Standardized station designs help patrons find their way in unfamiliar stations and are an aid to system efficiency as well as substantial system-wide equipment economies. Savings are possible in equipment, prefabricated units, and in special materials.

Each station layout and development, however, requires individual consideration because of many variables including structure type, passenger volume, and site adaptation, to name a few. A typical station site-development plan will illustrate most of these areas since they are generally present at every site, although their solution is different at each one.

1. Typical Station Development Plan

a. *Landscaping*

The need to pleasingly blend the station into its surroundings and make what the architects call an attractive visual entry is paramount in station design. This is true because the station affects both the patron and the non-patron. Landscaping does this by screening some areas, highlighting others, visually dividing larger areas to add character to accent or de-emphasize size, and by relating the overall site to its surroundings.

b. *General Design*

A paved pedestrian area should be provided, to ease congestion during peak hours and control cross-movements near the stations. Bus-loading and unloading zones should be near the entrances, and similar separate areas should be provided for automobile riders, thus isolating these feeder modes from each other as well as normal pedestrian traffic-patterns.

Ticket selling, preferably by automatic self-service equipment which codes the tickets according to the destination selected, should not interfere with arriving and departing patrons or be blocked by crowds at the track entry gates. The patron's ticket will be inserted into a slot to operate the entrance gate and the exit gate at his destination. Only a ticket coded for the particular station will operate the exit-gate door. At any other station the patron must resolve his problem by consulting an attendant or by telephone or TV service provided for these cases.

Passenger platforms should be at car-floor level and wide enough to handle the pedestrian flow to and from escalators, ramps, and stairs. Canopies extending over the cars should protect the platforms from the elements, thus encouraging passengers to be in a position for rapid loading, and minimizing the station time. Adequate lighting and information and directional signs are essential. Overpasses or underpasses may connect the platforms, but the latter must be well-lighted and have surveillance for passenger protection. Closed-circuit TV can be used here and on all platforms and other selected areas to monitor for distressed passengers, fare-evaders, and vandals.

Public toilets will be required as controlled by local codes and the amount of passenger traffic.

c. *Interior Traffic Flow*

Interior traffic flow is of major significance in a transfer point where people move between trains and between differing transportation modes. A typical arrangement will bring main lines to separate platforms, some of which may be at different levels. These multiple scheduled lines interfere with other long distance and local travel modes.

The station design must permit smooth pedestrian flow and minimal delay, consistent with cost. Details which contribute to this include the time-phasing between incoming lines to eliminate short-duration periods of congestion. Adequate elevator, escalator, and stair capacities must be provided, and these and the platform areas must allow for a reasonable patron waiting-time. While matching the system to the estimated peak-load capacity is desirable, the designer must consider the extra costs for providing this capability and weigh its advisability.

d. *Waiting Room Size*

The function of the waiting room varies according to the nature of the station, whether it is an outlying station, a suburban transfer point, an intercity station, or a metropolitan terminal. The outlying station and suburban transfer point do not need a large waiting room since most passengers will move directly between the trains and automobiles, and will not enter the station. The intercity station will need a larger waiting room because of infrequent intercity train schedules, and the passenger service-areas will also have to be more extensive. The metropolitan mass-transit terminal will have a smaller waiting area since the major traffic flows occur only twice daily during rush hours when the schedules dovetail well and few people have to wait very long for their train or bus. Some seating should be provided, however, for the very elderly and the incapacitated. Adequate pedestrian passage areas must be provided, however, to minimize local congestion spots during rush hours.

2. Site Selection Factors

Many factors govern the selection of a station site, and the interrelations between the factors can become very complex. Service to the community is the primary consideration, of course, and the accessibility of the site for both people and transportation modes is of first importance. The travel time between the station and the ultimate destination and the average train operating-speed on the system are also important in selecting locations—suburban stations tend to be 2 to 7 miles apart for these reasons, for example. Fast train schedules are hard to maintain if there are many stations.

Land-use and both train and local transit operational requirements must be considered, and the stations must be convenient to the population centers. Particular attention should be paid to the development potential around stations. Properly sited stations promote economic growth and enhance property values.

The service requirements which call for building a rapid-transit station at a given place can be confirmed by making a traffic-analysis study.

D. VEHICULAR PARKING AT STATIONS

Mass transportation will be widely accepted only if there is adequate well-marked, paved, and lighted parking areas for patron's automobiles. Larger stations in more densely populated areas may require parking controls to eliminate unauthorized parking, such as parking meters, toll booths, or windshield decals. Parking may be free in outlying areas where land is easily available, to encourage patronage.

The data in this section supplements that found in the report "Parking Facilities for Patrons at Passenger Stations."[1] Full advantage should be taken of any adjacent parking that is available at fairgrounds, regional shopping centers, stadiums, and other major interest-generators which draw crowds of people.

Detailed studies are important in determining the parking requirements for a given location, and to assure capacity for future parking demands. Charges for parking should be set to make the operations economically sound, but should not be so high as to make it unattractive to park there.

Both pedestrian and vehicular circulation should be arranged to enhance safety, reduce delay, and minimize conflict. Pedestrians are best accommodated by spacing the parking aisles so there are pedestrian aisles which connect with a central walkway leading directly to the station. This will help keep pedestrians out of the driveways. Vehicular parking in open lots will be eased by providing multiple vehicle lot-entries which lead directly to circulation aisles. At least one outbound lane should be provided for each 300 spaces and one inbound lane for each 500 spaces.

The stalls should have wheel bumpers to assure the pedestrian walkways are not infringed upon. An 8-ft 6-in minimum stall-width is considered acceptable since commuter patrons will carry little or no luggage and there will normally be only one departure a day from each space. A wider 9-ft stall is desirable for right-angle

[1] AREA *Proceedings*, Vol. 60, 1959, pages 294–8. Parking facilities are generally described, including geometric layout, entrance and exit arrangements, operation methods, paving and drainage, lighting and fencing, parking garages, and local zoning restrictions. Drawings are included for recommended aisle and stall dimensions, and a typical layout is shown for a parking facility.

parking, and about 10 ft is desirable for parallel parking. The stall length should be 18 ft, except when it is either lengthened for angle parking or extended to 22–24 ft for parallel parking. About 65 ft is required to accommodate two opposing stalls with driveway aisles for 90-degree head-in parking, which will yield a 29-ft-wide aisle and two 18-ft-long stalls. The overall distance can be reduced to 58 ft, however, if 60-degree parking is used.

Parking lots should be fenced and lighted for general safety and to discourage theft and vandalism. The lights can be clock-controlled or controlled by photoelectric sensors.

Proper cleaning and maintenance must be assured. The major items are snow removal, sweeping, pavement markings, and pavement repairs. These can be done by either the operating firm or by an outside contractor. Snow removal is highly important in the northern states and must be done before morning and after evening commuting hours.

Parking garages having a 7-ft minimum clear-height will normally have 9.5 ft to 10-ft distance between the floor levels. The ramp grades should not exceed 13 percent, and 7- to 8-percent grades are preferable. The grades should not exceed 5.5 percent where cars are parked on them.

The operation of garages and lots by experienced management personnel has proved its value in greater use and higher net revenues. The facility location and design should always be governed by operational needs. In addition to circulation, convenience, and economics, extra services should be considered such as attendants for police protection and aid in starting cars where simple difficulties arise.

E. RAIL ACCESS TO AIRPORTS

Trains have not been used to move passengers between airports and cities for a variety of reasons. An important one is that the airports have not commonly been located near rail facilities. Another factor is the relatively close location to cities has made it easier to go directly to the airport from home than to travel to a centrally located commuter rail head. This becomes more feasible and desirable, however, as airports continue to be located farther from metropolitan centers, and traffic congestion at the airports continues to cause patrons to spend as much or more time getting to and from the airport as they do in actual flight time.

A direct line between the central business district and the airport will be of only limited value unless it and the stations along the route are served by feeder lines. Such a line should be integrated into the rapid-transit system, therefore, since the suburban areas generate most of the airport traffic.

Extending existing or constructing new rapid-transit lines to the airport may be difficult in some cities where location, interface, and operating problems may be posed for both transportation media. Several new types of equipment are being developed which show considerable promise.

Advance Report of Committee 14—Yards and Terminals

Report on Assignment 5

Recent Developments in Yard Lighting

C. E. STOECKER *(chairman, subcommittee)*, R. P. AINSLIE, R. F. BECK, A. E. BIERMANN, W. P. BOOTHROYD, G. E. BURNS, B. E. BUTERBAUGH, G. H. CHABOT, J. F. CHANDLER, M. K. CLARK, F. D. DAY, H. L. HAANES, D. C. HASTINGS, WM. J. HEDLEY, L. J. HELD, A. L. HUNTER, C. J. LAPINSKI, S. N. MACISAAC, H. J. MCNALLY, J. M. RANDLES, R. J. SAMOSKA, L. G. TIEMAN, HOWARD WATTS, JR., P. C. WHITE, J. R. ZEBROWSKI.

Your committee submits the following report, as information only, pertaining to types of lighting used in present yard operation with the recommendation that the subject be discontinued.

Proper lighting in railroad yards is essential to promote safety, expedite operation, reduce pilferage and damage to equipment.

Systems most generally used in lighting railroad yards are:

A. Directed high-mounted lighting with following characteristics:
1. Minimized physical and visual obstructions.
2. Light distribution flexible.
3. Long effective range.
4. Maintenance restricted to a few locations.
5. Aiming of individual light units.
6. Electrical distribution system serves a small number of concentrated loads.

B. Distributed low-mounted lighting with following characteristics:
1. Uniformity of illumination.
2. Better utilization of light.
3. Reduction of undesirable shadows.
4. Less critical aiming.
5. Reduced losses due to atmospheric absorption and scattering.
6. Electrical distribution system serves a large number of small distributed loads.

In reports received from member railroads, it was noted that the type of lighting systems in different parts of the railroad yard is related directly to the seeing tasks performed in that particular area.

In receiving and departure yards some of the working tasks consist of bleeding, and checking air lines, journal boxes and safety appliances. Reports indicate 1000-watt mercury-vapor lights used in most yards are mounted on towers 100 to 120 ft in height and spaced at 100 to 175 ft centers.

In hump areas the tasks consist of checking car numbers and inspection of cars and running gear; 1000-watt mercury-vapor lights are most frequently used with directed lighting, spaced at 100 to 300 ft centers.

In classification yards, cars must be observed beyond the clearance point of each track. In the bowl end of classification yards, a switchman must be able to see switch points and have sufficient light for safe walking.

The majority of roads report using 1000- to 1500-watt mercury-vapor lights on 100 ft towers spaced at 100 to 800 ft centers.

In trailer and in auto loading and unloading areas the working tasks require sufficient light for tie-down of trailers or automobiles. Lighting most frequently used is 1000-watt mercury-vapor lights on short poles spaced at anywhere from 45 to 150 ft centers.

Around yard office areas, including parking lots, the popular light is mercury-vapor, but varying from 400 watts on high poles, 100 ft centers, to 1000 watts on high poles, 300 ft centers.

In mechanical shop area and fueling points most railroads use 400- to 500-watt mercury-vapor lights on high poles spaced at 75 to 100 ft centers or 1000-watt lights on corner of buildings.

For security purposes the popular lights are 100- to 400-watt mercury-vapor lights on 65-ft poles—150 to 200 ft centers.

Apparently mercury-vapor lights are desirable since no railroad member reported any future plan to make any change in this type of fixture, while several reported that mercury-vapor had been a replacement, in the past few years, for incandescent lights. The incandescent lights required a change-out every 10 to 15 weeks compared to 18 to 24 months for mercury-vapor. The self-ballast mercury-vapor or metallic-vapor lamps reportedly are favorable in cost, efficiency and maintenance. One member reported an estimated savings of $30 per fixture on maintenance along with a savings of approximately 50 percent on electricity cost per year.

Advance Report of Committee 22—Economics of Railway Construction and Maintenance

Report on Assignment 2

Economics of Methods and Procedures for Disposal of Discarded Cross Ties

B. J. Worley *(chairman, subcommittee)*, Arlie Bornhoft, C. J. Bryan, L. B. Cann, Jr., S. A. Cooper, L. C. Gilbert, Wm. Glavin, B. G. Hudson, T. L. Kanan, J. M. Lowry, F. L. Rees, Mike Rougas, A. E. Shaw, Jr., J. T. Ward.

Your committee has made an exhaustive study of this assignment and submits as information the following report of methods and procedures for disposal of discarded cross ties. Some of these are in use on railroads today and some are suggested methods not yet being utilized other than experimentally.

To assist this committee in formulating the information, a questionnaire was sent to 63 representatives of 29 railroads and four engineering consultants. Of these, 25 replies were returned reporting tie disposal performance on 19 railroads in 1971. These roads are representative of both large and small lines.

The 25 replies indicated a total renewal of 10,145,375 cross ties in 1971. Of these 2,848,625 (28 percent) were recovered in one piece and 7,296,750 (72 percent) were recovered in pieces. The percentage of cut ties has increased substantially since a similar report was made in Bulletin 616, November 1968, pages 174–176.

Thirteen of the 19 railroads reported a small percentage of recovered ties burned at site; however, the reporting railroads collectively burned 5.4 percent of the whole ties and 22 percent of the pieces. Only one road reported a large percentage of ties burned at the site. Cost of tie disposal by burning averaged 15 cents per tie when handled manually and 8 cents when handled mechanically.

Some states in which the reporting roads operate do not permit open burning of ties. Other states will allow open burning by permit only. It is apparent that granting of such permits will become more restrictive in the future.

Of the total ties renewed, 3,655,695 were left at the site to decay. This amounted to less than one percent on one railroad to 90 percent on another. Eleven of the 19 reporting roads still leave better than 40 percent of the ties at the site.

Seven roads have reported disposal of ties by burial, but this amounts to less than 4 percent of the total ties renewed. Several types of machines are used for burial, including bulldozers, backhoes, cranes and front-end loaders. Cost varies greatly, with the average between 30 cents and 50 cents per tie depending on the method used and the distance hauled.

Ties picked up and hauled to disposal areas amounted, on one railroad, to as much as 50 percent; however, of the total ties reported, less than 2.5 percent were disposed of in this manner.

The cost of loading whole ties averaged 45 cents per tie and 30 cents per tie for loading pieces. The average cost of unloading whole ties averaged 45 cents per tie and for unloading pieces of ties averaged 10 cents per tie.

Selling or giving away old ties is quite universal. Approximately 16 percent of the total ties recovered are disposed of in this manner. Sale prices vary greatly for whole ties ranging from 15 cents to $3 each. Pieces are given away wherever possible. A number of complications arise from selling or giving away ties. One is the need for accounting for sales and handling receipts. Permitting buyers to enter railroad property creates a liability on the part of the railroad for the safety of the buyer and his equipment. Any such arrangement should have legal sanction and railroad supervision.

Ties disposed of mechanically was done on only four reporting roads, and apparently proved to be quite expensive. Very few whole ties have been shredded and no cost figures are available; however, cost of disposing of ties in pieces ranges from $0.75 to $1.34 per tie. Cost variance is reflected in direct proportion to the number of ties handled by a machine daily and the amount of down time. Only 1.5 percent of the total ties removed were handled in this manner.

There are various types of tie destroyers on the market. One, in limited use, is an incinerator which permits controlled burning. The incinerator consists of an air manifold through which a curtain of air is directed through nozzles across the top and down into a prepared trench. The air is fed into the manifold from a high capacity blower. This curtain of air is not only a source of oxygen for accelerated combustion, but also serves as a blanket which retains the smoke, gases and other particulate within the trench until they also are consumed by the extreme heat so generated. Auxiliary fuel is necessary to start the process only. The trench must be constructed to an accurate dimension with the bottom reasonably level and sides perpendicular. The length should accommodate eight foot increments of manifold. Permanent installations should be refractory lined. The manufacturer claims that temporary trenches need no lining except where unstable soil conditions would require a liner to maintain perpendicularity of sides. The air supply is generated by an aerodynamically designed centrifugal fan with backwardly inclined blades, powered by a diesel engine. The fan delivers a great volume of air at a high static pressure. The air stream (blanket) is directed downward across the pit at arc angle of 30 deg from the horizontal, and is deflected downward and into fire by the sides of the trench. The manufacturer claims that ties can be consumed at the rate of about 100 per hour in a 40-ft trench.

Permanent installations would be desirable for terminal areas to incinerate ties generated there, as well as ties shipped to the incinerator from outlying areas.

Temporary installations would be more adaptable in localities in the near proximity to large tie renewal projects. The temporary pits located close to a tie renewal project would eliminate haul. The burner unit described can be made portable.

Tests run on a pilot scale trench incinerator by the U. S. Department of Health & Welfare indicate that except, for nitrogen oxides, emission levels from the incinerator may be acceptable if rigid operating controls are predetermined for the specific refuse materials.

The trench incinerator may be applicable to the disposal of low-ash, high-heat-content refuse under rigidly controlled operating conditions where the nature and the quality of the refuse is carefully considered. Since it is apparent that acceptable levels of particulate emissions can easily be exceeded without a noticeable change in plume appearance, standard methods and criteria to obtain good operating control of particulate emissions must be developed.

Several machines are being offered on the market which use the principle of grinding or shredding the whole ties or pieces of ties into chips and blowing or conveying them out onto the right-of-way. They are track mounted. One machine includes a tie handling boom to pick up ties, a conveyor feeder to deliver ties to the grinder, the grinder mechanism and a conveyor for disposing of chips onto the right-of-way, all mounted on a single frame.

The grinder has three main parts—a rotating drum 4 ft in diameter and about 4½ ft long, a pressure-loaded anvil and a pressure-loaded feed tray.

The outside periphery of the drum is studded with rows of expendable and replaceable carbide-tipped cutter bits. Meshing with these teeth is a series of similar cutter bits mounted on the anvil. Tie chunks on the feeder tray are continuously urged against the rotating drum which cuts away the exposed surface of the ties. The forces resulting from this cutting action urge the ties in a sliding movement along the feed tray against the anvil. Here the shredding action is completed by the cutter bits.

Two discharge belt conveyors, one on each side of the machine, dispose of the tie chips along the right-of-way. These reach 21 ft from the track and may be adjusted to any angle desired. Each discharge conveyor is fitted at its outer end with spreader devices, which disperse the tie chips.

Tie chunks are delivered to the feeder tray by a feeder conveyor located between the rails at the front end of the machine. A control deck is located directly above the feeder tray and the operator can observe all operations and movements of the tie chunks as they move over the feeder tray and into the machine.

The machine is powered by an engine capable of delivering 180 hp at 2000 rpm. Travel speed ranges up to 25 mph.

The feeder conveyor for this machine is fed by a tie handling boom. Tests run to determine performance capability on this machine indicate a disposal rate equivalent to 100 ties per hour. Manufacturer claims a capability of up to 150 ties per hour. This capability rate is apparently under ideal conditions, and actual disposal will depend upon the proximity of the number of ties to be disposed of to the machine, the down time of the machine, the working time allotted to the machine on the track during the day and a number of other operating problems. Actual performance on a high-speed track in a normal tie program indicates a rate of no more than 300 to 350 ties per day. Scattering of chips on the right-of-way can possibly create a fire hazard although tests show the chips are spread thinly enough to hold such a hazard to a minimum. Some states, however, have objected to the chips, and it was reported that in one state a railroad was required to cover the chips with dirt.

Another machine observed is similar in its method of tie destruction. Both machines feature tie handler booms mounted on the same frame and operated as a unit in itself. The machine is operated by one man. One or two laborers are required to pile tie pieces and to straighten ties or tie pieces that become lodged in the conveyor.

This machine is self-propelled, can travel at 25 mph and work up to 10 mph. The tie handling boom can swing to 200 deg and can handle ties up to 12 in by 12 in by 15 ft long, including switch ties. The manufacturer claims machine will pulverize butts or whole ties interchangeably at a rate of 27 ft per minute. Processing rate is dependent on several factors such as operator proficiency, condition of the ties, whether whole or in pieces, and placement along the track. It will grind spikes, S-irons, and imbedded ballast, but has shear bolt protection against large tramp steel such as tie plates.

This machine is equipped with a blower and a swivel discharge to blow the small ground up pieces of cross ties to the desired location. The operator controls the position of the swivel discharge from the cab and can direct the material to either side or to a hopper car.

This machine is powered by a 300-hp V-8 diesel engine.

The two machines described above range in cost from $60,000 to $65,000.

Your committee inspected still another type of tie destroying machine for destroying old ties and reports the following:

The machine consists of a flat bed approximately 10 ft long by 4 ft wide. Mounted at the bottom of the bed is a revolving cutter which is the full width of the bed. The cutter is studded with several rows of carbide-tipped teeth.

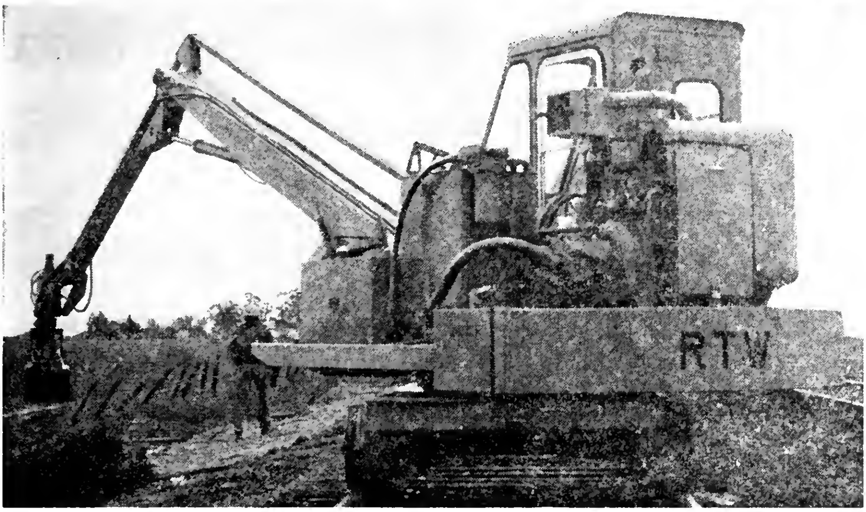
A large box without a bottom approximately 4 ft by 6 ft by 4 ft deep, is mounted over the flat bed. Tie pieces to be destroyed are placed in the box by a tie handler, which moves back and forth from one end of the bed to the other. As it does the tie pieces resting on bed pass over the cutter and with each pass up to ½ in of the bottom layer of the pieces are cut up. Chips fall onto a conveyor belt which discharges along the right of way. This machine is powered by a 4-cylinder diesel engine delivering 94 hp at 2200 rpm.

The tie destroyer was purchased by a railroad as a trailer unit and modified for rail use at total cost of approximately $30,000. As observed, the unit can be used either on-track as a self-propelled machine or off-track as a trailer unit. The machine operates on level track at a walking speed but can travel up to 20 mph. The unit is capable of destroying tie pieces at the rate of 60 to 90 ties per hour. It requires one operator for the tie destroyer, plus one man to run a tie handler used in feeding the pieces.

It can be concluded from the questionnaire that the bulk of discarded cross ties are either left at the site to decay or are being burned, sold or given away.

It is quite evident that open burning of ties will in the future be prohibited and that either mechanical means or controlled burning will be necessary to dispose of old ties.

TIE HANDLER from RTW...



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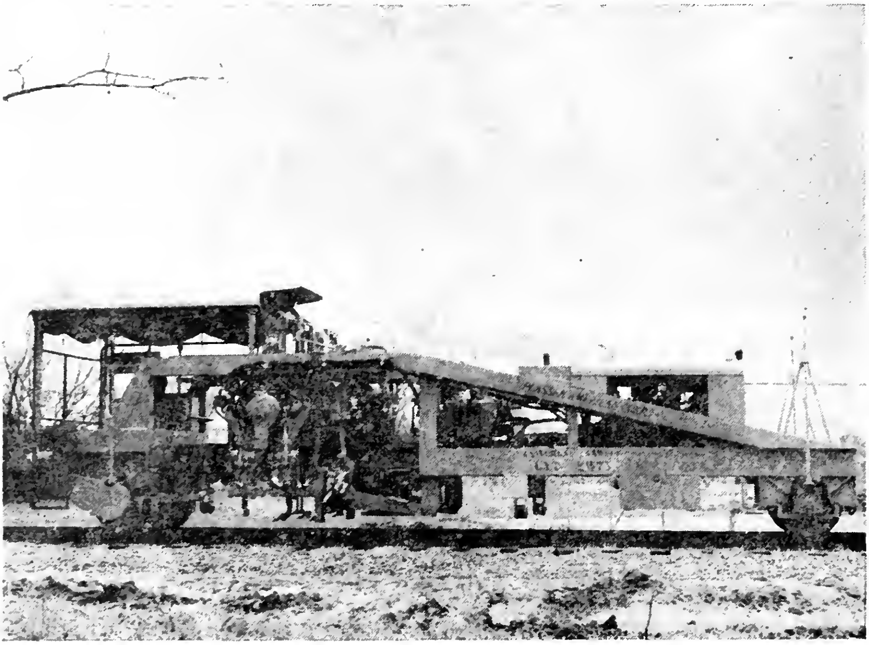

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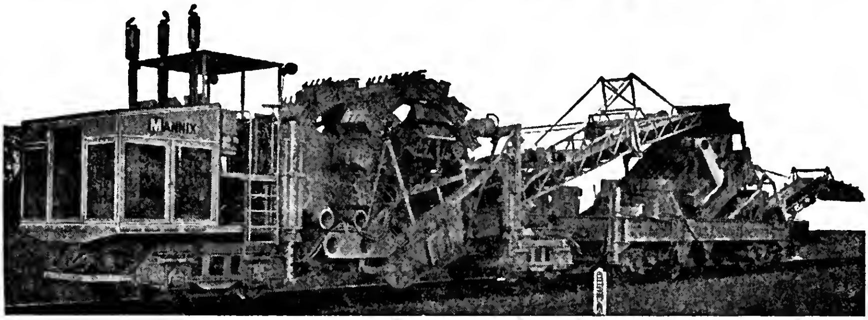

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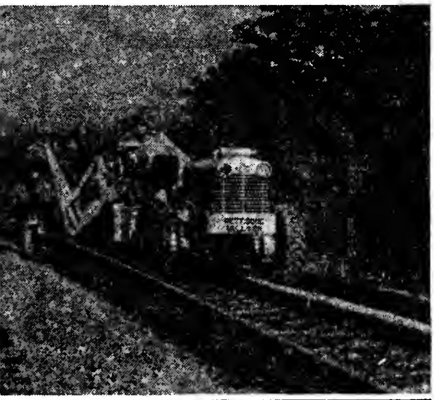
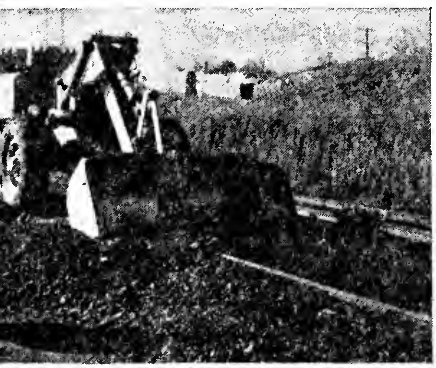


LAYING WELDED RAIL



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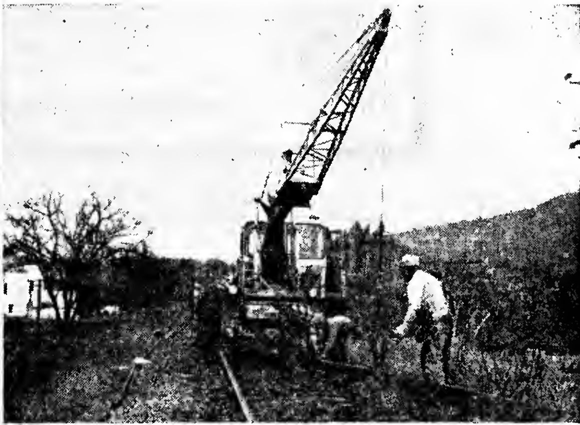

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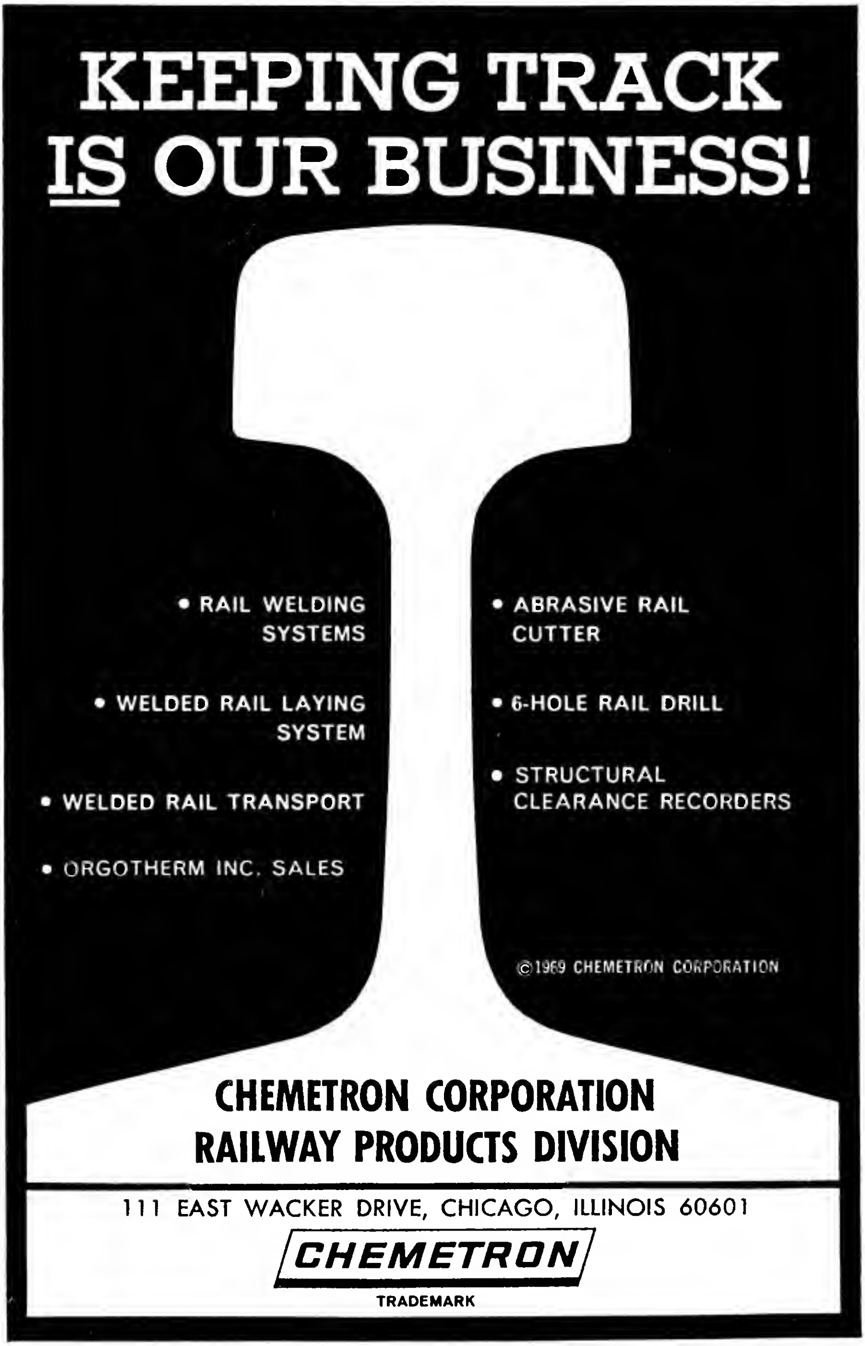
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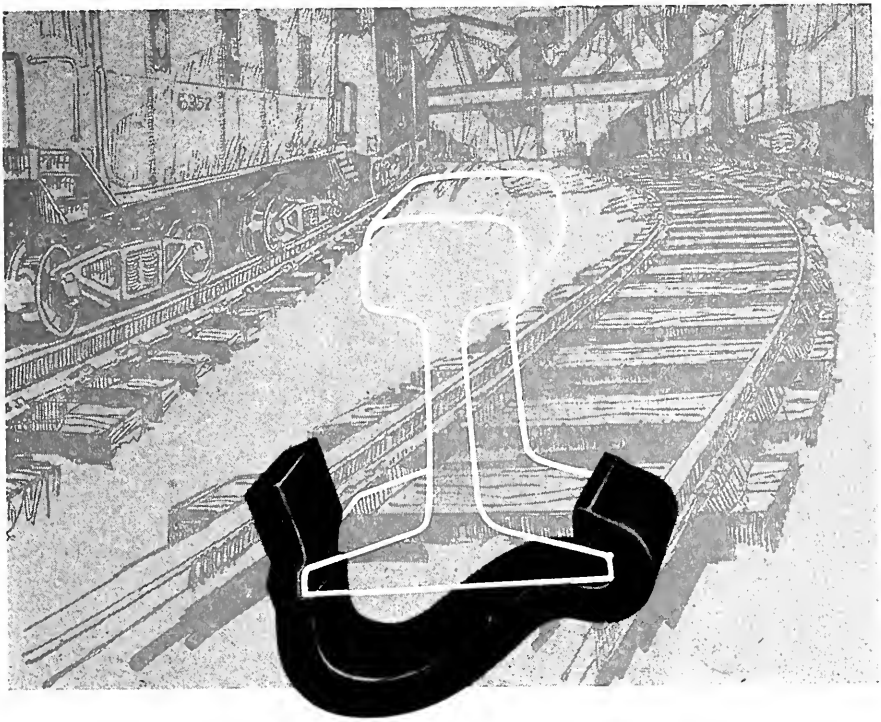

DISCUSSION

Some Aspects of Service Developments in Rail Head Metal[1]

DISCUSSION BY R. G. READ[2] (M '71)

I was rather interested in the Paper 72-633-13 by R. J. Henry in AREA Bulletin 633 entitled "Some Aspects of Service Developments in Rail Head Metal," and in particular the section on rolling contact life as a function of stress.

Unfortunately I did not receive my copy of the Bulletin until late October which was after the closing date for discussion, but I would like to make some observations if I may.

I head the Railway Section of a large firm of mining and engineering consultants in Australia and over the past 5 years we have designed and supervised construction of a number of railway systems, including the Hamersley Iron Railway which is currently being expanded to transport 40 million long tons of iron ore per year and the Weipa Bauxite Railway which is planned to transport up to 20 million long tons of bauxite per year.

On the Hamersley Railway we are operating unit trains of 160 cars, each car with a gross weight of 263,000 lb and a tare weight of 45,000 lb. The railway was designed basically around AREA recommended practice, but even though to date just over 100 million gross tons of traffic has passed over the track, significant rail damage is occurring and rail life is only a fraction of that given by the AREA rail wear formula.

In the case of mineral railways where only unit trains operate, with loaded trains in one direction only and with every axle load at 66,000 lb, and when annual tonnage is high, rail life is dictated by fatigue criteria rather than by wear, except on the sharper curves. This is showing up on the Hamersley railway where incidentally rail corrugation is also a major problem.

The fatigue graph shown in Fig. 12 of the above-mentioned paper does not project far enough down to be of special interest to railway engineers and in fact could be misleading if the straight lines were extended. In actual fact, if projected downwards, these lines would indicate the normal endurance properties of a typical S-N fatigue curve. In the case of the 263,000-lb car on four axles and 38-inch wheels, it would appear that the maximum internal shear stress in the rail is at such a level that for standard AREA rail a relatively small reduction in stress will result in a much greater fatigue life of the rail.

The concluding remarks of the paper by C. J. Code entitled "Wheel Load, Wheel Diameter and Rail Damage" in the AREA Proceedings, Vol. 61, 1960, are particularly relevant. It was from these comments by Mr. Code, and the problems we were having with rail on the Hamersley railway that I investigated various literature in more detail and have come to the conclusion that with the introduction and increasing use of heavy unit trains hauling high annual tonnages, railway engineers will be facing rail damage problems of a vastly increasing number unless steps are taken to avoid such an occurrence.

In this connection I was recently invited to give a lecture to railway engineers

[1] Paper by R. G. Henry, Engineer, Alloy Deve'opment Section, Homer Research Laboratories, Bethlehem Steel Corporation, published in Bulletin 633, June–July 1971.

[2] Senior Civil Engineer—Railways, Minenco Pty. Limited, Mining and Engineering Consultants, Melbourne, Australia.

here in Australia on the problems with rail for high intensity mineral traffic and I have attached a copy of my lecture [printed below] with the hope that perhaps my comments might generate additional interest in a subject which will become increasingly vital as unit train operations become more widespread.

The Rail for High Intensity Mineral Traffic

By R. G. READ

Minenco Pty. Limited
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Melbourne, Vic., Australia

Introduction

As a result of the mining boom in Australia, increased pressure has been placed on railway transportation to handle large tonnages of mining products in long and heavy trains. Whereas in the early 1960's the heaviest trains were 2,000 tons hauled by 2000-hp. locomotives and axle loads were about 20 tons, we are now faced with 3600-hp. locomotives hauling 20,000- to 30,000-ton trains with 30-ton axle loads. These heavier trains, which bring about the advantages of lower cost, high-volume transport, are necessary if our mining products are to remain competitive on the world market.

In recent years, however, the pressing demand for bigger and bigger wagons has been met simply by making them higher, longer, wider and heavier, without any real analysis of the effect on such components as rail, fastenings, sleepers, wheels, bogies, etc.

In this address I will consider only the rail and indicate briefly some of the damaging effects that heavy mineral trains have on it, and suggest possible means of overcoming the problems.

Rail Weight

The usual method of establishing what rail section should be used on a particular railway is to determine the required section modulus from the theory of a beam on an elastic foundation. Sometimes a larger rail section might be chosen with the idea of achieving greater wear life. However, when increasing axle loads from 20 tons to 30 tons, the mode of rail failure can change from one of bending to one of yielding of the rail head through excessive shear stresses. Once the shear strength of the rail steel is exceeded, no amount of increase in rail weight will prevent yielding from taking place. Thus, an increase in axle loads is not necessarily accommodated by an increase in rail weight.

Rail Joints

We all know that on railways carrying general freight traffic, the ordinary fish-plated joint represents a significant proportion of the total track maintenance costs. On mineral railways with heavy axle loads and high tonnages, it becomes more of a problem. The heavier axle loads amplify rail end batter, and the incidence of fatigue cracks around bolt holes, increases.

There is therefore a greater need to weld the rail as it is laid, and to purchase rail without stress-raising bolt holes. A higher standard of flashbutt and thermit welding is necessary both to withstand the higher axle loads and to ensure minimum dynamic loading through vertical and horizontal misalignment. In order to achieve better quality welds, standards of inspection must be raised through increased use of ultrasonics and other means.

Insulated Joints

As annual tonnages increase, the need for signalling and C.T.C. arises. After carefully eliminating rail joints by welding, it is illogical to introduce insulated joints which are more prone to failure and are more of a maintenance problem than the ordinary fishplated joint. Even if a satisfactory joint were available, the introduction of a gap and bolt holes in the rail, seriously reduces the life of the rail in that area. The introduction of a system of signalling which avoids insulated joints becomes more pressing.

Rail Corrugations

Rail corrugations have been known to railway engineers for some time, but on mineral railways where the trains are made up of unvaried rolling stock, running at almost constant speeds, the problem is amplified. The heavier axle loads accelerate formation of corrugations, increase dynamic overloading of the rail head and aggravate the effects of fatigue. Progressive deterioration occurs in certain well defined areas because of the uniform configuration of unit trains whereas if the same loadings were of a random nature, corrugations would be less likely to occur.

Length of Rail

Related to rail joints is the length of rails. On most railways, transport of long welded rail is common and there is no reason why rail should not come from the steel mills in longer lengths. If we are intending to continuously weld the rail, it is senseless to cut it during manufacture so that we can weld it together again later.

A rail rolled 90 ft long is preferable to two 45-ft rails welded together because of the unavoidable misalignments in the weld and the fatigue-prone welded area. Also, the cost saving by using 90-ft-long rail can be quite substantial. Fig. 1 indicates the percentage cost advantage of using 90-ft rails compared with 45-ft rails for various weld costs.

Wheel–Rail Contact

I would now like to discuss in a little more detail, the subject of wheel–rail contact.

Recommended Wheel Loads

In 1940 the American Iron and Steel Institute recommended limiting wheel loads on wagons to a range 650 lb to 800 lb per inch of wheel diameter depending on the size of wheel. Unfortunately the AAR mechanical engineers did not accept this, with the result that more and more heavier wagons have since been introduced into U.S. railroads.

In 1958 the Joint Committee on Relation Between Track and Equipment made the recommendation that wheel loads be limited to 800 lb per inch of diameter. As this would have restricted many wagons already in service, there was a lot of opposition to it, and a modified recommendation as shown in Fig. 2 was submitted.

There is a misconception that compliance with these recommended wheel loads will prevent premature rail head failure from overloading. This is not so. The recommended loads were a compromise at the time to enable large numbers of heavy wagons in the U.S. railroad systems to remain in service.

FIG. 1

% COST ADVANTAGE OF USING 90 FOOT COMPARED WITH 45 FOOT RAILS

Cost of Weld	Weight of Rail in lb/yd					
	136	132	119	107	94	82
	%	%	%	%	%	%
$10	4.8	4.9	5.5	6.1	6.9	7.9
$15	7.2	7.4	8.2	9.1	10.4	11.9
$20	9.5	9.8	10.9	12.1	13.8	15.8
$25	11.9	12.3	13.6	15.2	17.3	19.8
$30	14.3	14.8	16.4	18.3	20.8	23.8
$35	16.7	17.2	19.1	21.2	24.2	27.7
$40	19.0	19.7	21.8	24.3	27.6	31.8

NOTE : 1. Cost of rail assumed to be $115/ton.

2. Transport costs per ton assumed to be the same for 90 ft. rail as for 45 ft. rail.

FIG. 2

RECOMMENDATION OF JOINT COMMITTEE ON RELATION BETWEEN TRACK AND EQUIPMENT

29TH APRIL, 1959

Maximum Load on Wheels of Various Diameters

Nominal Wheel Dia. (inches)	Nos. per inch	Wheel Load
33	800	26,400
36	810	29,200
38	820	31,200
40	825	33,000
42	830	34,900

In many countries the contact pressure is expressed as P/D ratio where P is the axle load in tons and D is the wheel diameter in feet. Typical ratios for some systems are:

British Railways	5.5
SNCF (France)	5.4
Japanese National Railways	5.5 to 6.0
USSR	6.7
Australian State Systems	5.5 to 6.5
AAR Joint Committee Recommendation	8.8
263,000-lb wagon	9.3

It can be seen that American practice is not in line with that of many of the other developed countries and this is clearly evidenced by the fact that while shelling of rail is fairly common in the United States, it is rarely experienced in Europe.

Internal Shear Stresses

The most damaging effect on the rail of high wheel loads is the high shear stress beneath the surface of the rail. Thomas & Hoersch show that the maximum shear stress can be obtained by solving the problem of crossed cylinders and is approximately equal to—

$$\text{Max shear stress} = \frac{11{,}750\ P^{0.33}}{R_1^{0.271} \times R_2^{0.396}} \qquad (1)$$

When this shear stress reaches a limit which is specified by the Tresca or Von Mise criteria, yielding of the steel takes place. This aspect is covered in a later paper by Dr. Mair. Shear stress distribution below the rail surface is shown in Fig. 3. Maximum shear stress occurs not at the surface, but at a depth of between 0.1 inch and 0.2 inch below the rail surface. At this location, if overloading occurs, internal fissures form and develop into cracks which propagate to the surface and rail head degradation results.

The AAR recommended wheel load with 50% impact results in maximum shear stresses varying between 50,000 psi for the worn wheel condition to 67,500 psi for the new wheel condition. These shear stresses are too high for 75,000 psi yield strength rail to withstand without causing degradation of the rail head.

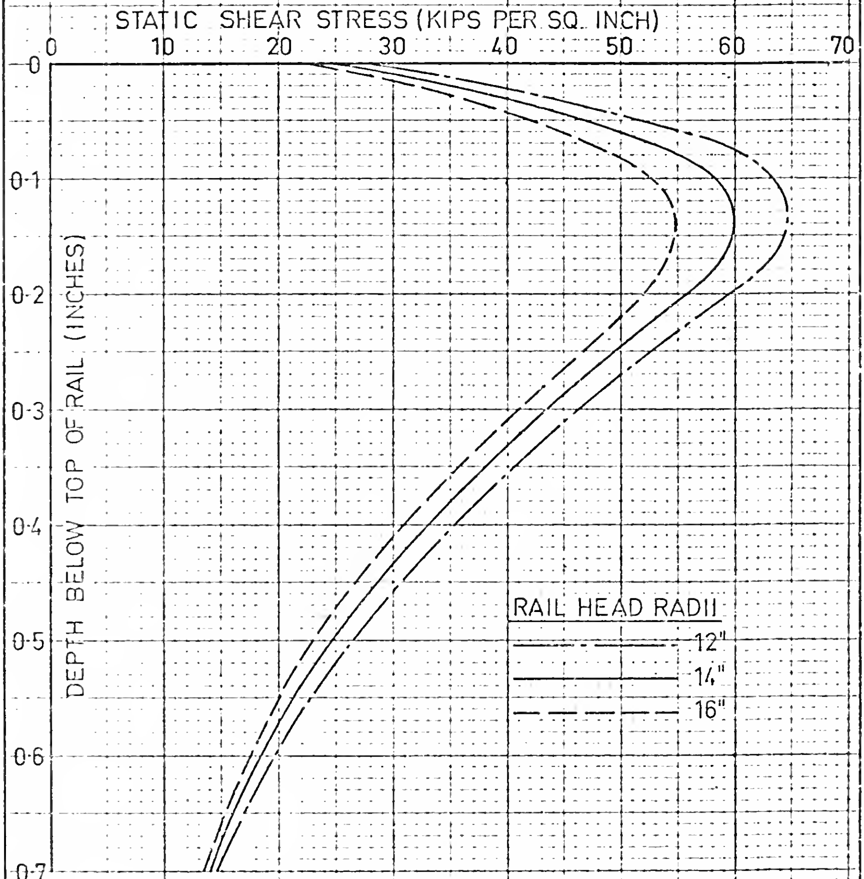
Solution of Problem of Excessive Shear Stress

It can be shown from equation 1 that the solution to the problem of excessive maximum shear stress can be achieved by reducing wheel load, increasing rail head radius, increasing wheel diameter, or increasing shear strength of the rail steel.

In order to achieve a significant reduction in shear stress, a substantial reduction in wheel load is necessary, because the stress is proportional to the cube root of the wheel load. Likewise, large increases in wheel diameter and rail head radius would be necessary.

An effective method of reducing wheel loads is to increase the number of wheels under the wagon. If two 3-axle bogies were used under a 120-ton-gross wagon instead of two 2-axle bogies, axle loads would be reduced from 30 tons to 20 tons, and the excessive wheel load problem would no longer exist.

Increasing wheel diameters raises problems of mechanical design and increased unsprung mass which is undesirable from the track point of view.



MAXIMUM SHEAR STRESS PROFILE

WHEEL RADIUS = 19" WHEEL LOAD 32·2 KIPS

NEW WHEEL AND NEW RAIL CONDITION

FIG. 3

FIG. 4

WHEEL/RAIL CONTACT PRESSURES (p_{max}) AND RAIL YIELD

STRENGTHS OF VARIOUS ORE HAULING RAILWAYS

Railway	Rail Type	Gross Wagon Weight (tons)	Worn dia. of Wheels (inches)	Wheel Load (lb)	Contact Pressure p_{max} p.s.i.	Yield Strength p_{max} p.s.i.	$\frac{p_{max}}{f_y}$
A.A.R. recommended wheel load		111.4	36	31,200	205,763	75,000	2.74
Hamersley	Standard carbon 136 lb/yd	117	36	32,800	209,173	75,000	2.79
Quebec North Shore (Canada)	Standard carbon 132 lb/yd	114	32	32,000	213,488	75,000	2.84
Orinoco Mining (Venezuela)	Standard carbon 132 lb/yd	114	29	32,000	220,219	75,000	2.94
	Treated rail 132 lb/yd	114	29	32,000	220,219	115,000	1.91
Vitoria Minas (Brazil)	Standard carbon 115 lb/yd	114	29	32,000	220,219	75,000	2.94
	Treated rail 115 lb/yd	114	29	32,000	220,219	115,000	1.91
Miferma Railway (Mauritania)	Standard carbon UIC (S54)	100	36	28,000	184,823	73,960	2.50
Lamco (Liberia)	Standard carbon 132 lb/yd	112	34	31,400	209,704	75,000	2.80

It should be noted that all our calculations are based on a matching wheel taper and rail inclination, and any mismatch is the surest way to encourage shelling.

Another approach to the excessive shear stress problem is to design the rail to suit wheel loads, rather than trying to restrict loads to suit the rail. This can be done by increasing the shear strength of the rail steel. A relatively small increase in shear strength would permit a significant increase in permissible wheel load.

Fatigue

Even if the stresses in the rail head are below the allowable design stress, it is possible for the rail to fail in fatigue. On general railway systems fatigue cracks around bolt holes are well known. As axle loads are increased, these cracks become more frequent and fatigue cracks in the rail head occur. Internal fatigue fissures originating from the point of maximum shear stress develop into defects which are dangerous because they are invisible during the incubation period, but are now fortunately detectable with ultrasonic equipment.

Fig. 5 is a typical "stress vs. cycles to failure" fatigue curve on a semi-logarithmic scale, for rail steel with a yield stress of 75,000 psi. In the case of an AAR-recommended wheel load, the rail fatigue life is approximately 6 million cycles or about 140 million net tons. It will not be until this tonnage is reached that rapid degradation of the rail head occurs. This degradation will first manifest itself in areas of high impact loading such as at rail joints and welds, and as time passes the entire length of rail will begin to degrade.

Earlier your attention was drawn to the fact that maximum shear stress increases only in proportion to the cube root of the load. It can be seen from Fig. 5, however, that in the range of stresses applicable to AAR-recommended wheel loads, and 75,000 psi yield strength steel, the life of the rail to failure decreases very sharply for even a small increase in stress. Or conversely, a small reduction in shear stress (or wheel load) causes a large increase in the life of the rail to failure.

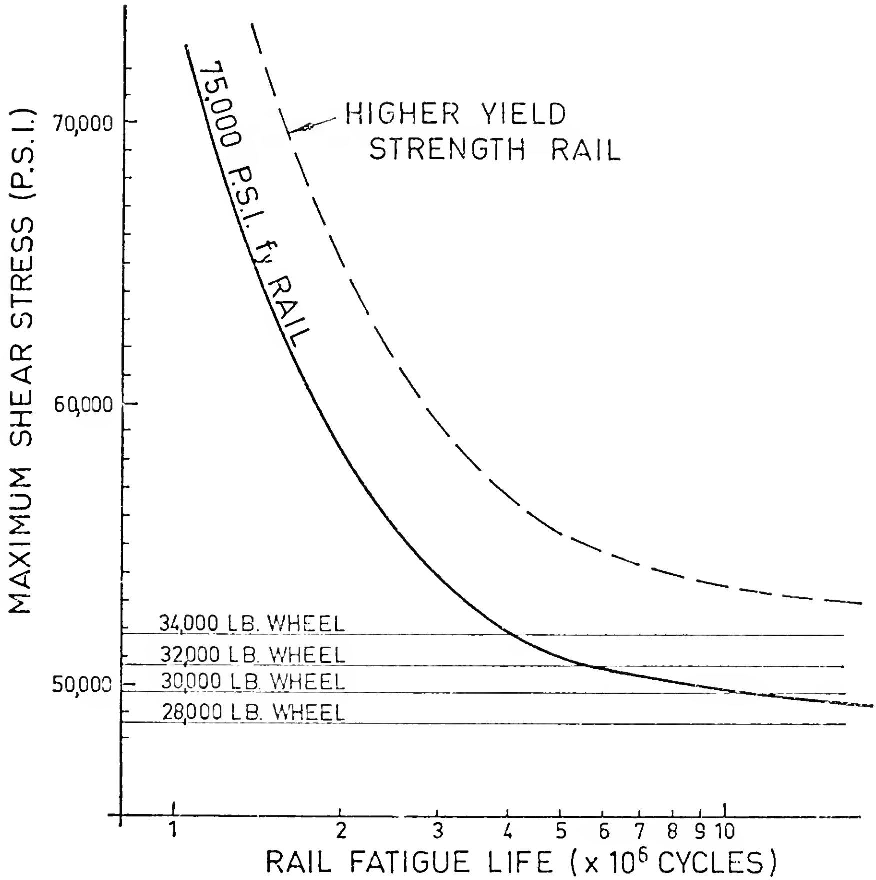
Rail Life

The AAR wheel load gives a rail life to failure of approximately 6 million cycles or 140 million tons. What is this in terms of years of service? On a general railway system where annual tonnage is 2 million tons, the 6 million cycle rail life represents a life of about 70 years before fatigue becomes a problem. On the other hand a mineral railway handling 50 million tons a year will get less than 3 years service from its rail.

Rail life to failure in years as a function of annual tonnage is shown in Fig. 6 for two different 38-inch wheel loads. Superimposed on this graph is the AREA rail wear formula for tangent track, which indicates rail life if wear is the only criteria.

It can be seen that for annual tonnages up to 5 million tons a year the total number of cycles is not sufficient to cause fatigue failure before the rail wears out. There is no advantage therefore in decreasing the wheel load from, say, 32,000 lb to 30,000 lb because rail life at this tonnage level would be dictated by wear. In the case of higher tonnages, however, the same reduction in wheel load would increase rail life.

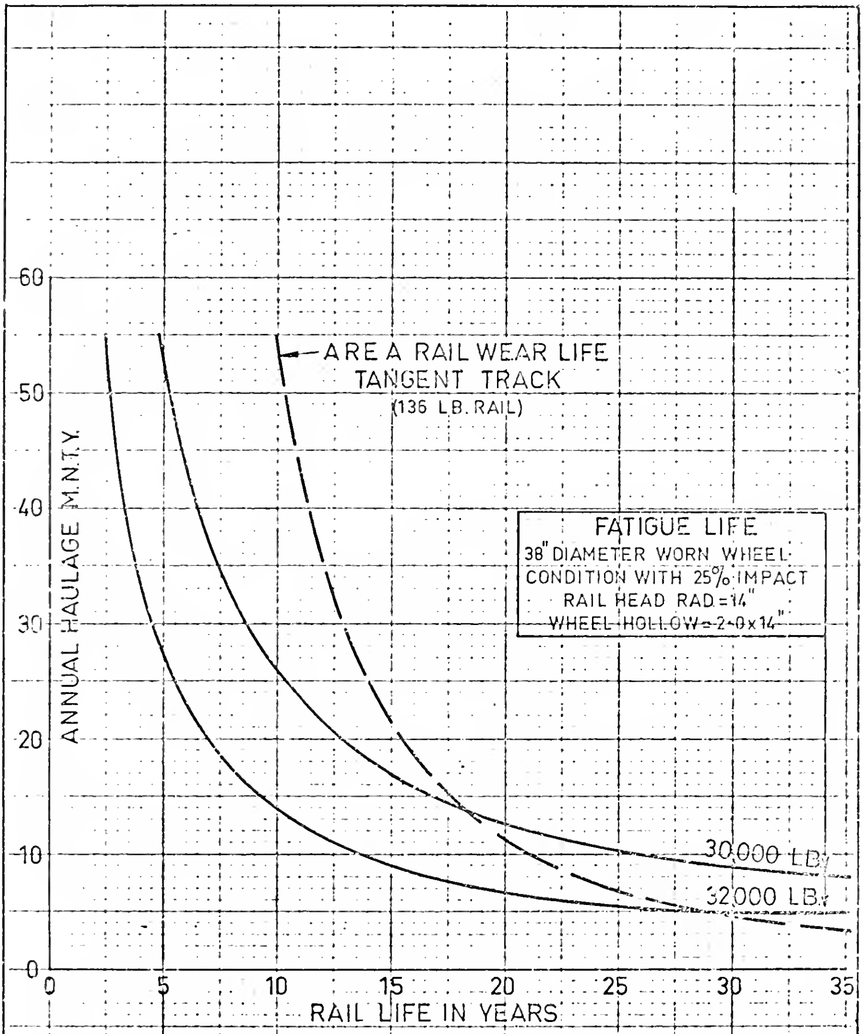
Considering a 30,000-lb wheel load on 136-lb rail, we find that up to an annual tonnage level of about 15 million tons rail life is dictated by wear whereas above a 15 million tons a year level, rail life is dictated by fatigue failure.



RAIL FATIGUE LIFE AS A FUNCTION OF MAXIMUM SHEAR STRESS

38 DIAMETER WHEELS, 14 RAIL HEAD RAD.
WORN WHEEL CONDITION, 25% IMPACT

FIG. 5



RAIL LIFE AS A FUNCTION
OF ANNUAL TONNAGE
FIG. 6

A rather interesting observation is that if annual tonnage levels are of the order of 5 million tons or less, rather higher axle loads can be handled without noticeable damage to the rail head; whereas at higher tonnage levels, in order to prevent damage during the normal life of the rail, axle loads must be significantly lower.

In practice, however, we have the anomalous situation where the low tonnage railways have low wheel loads while the high tonnage mineral railways have excessively heavy wheel loads.

Wheel–Rail Contact Pressures

Although it is not the high wheel–rail contact pressures which cause premature failure of the rail head, but rather the shear stresses, it is convenient to express desirable limitations in terms of the former. Fig. 4 compares a number of recently constructed mineral railways and shows wheel loads, contact pressures, rail yield strength and the ratio of contact pressure to yield strength of the rail steel.

The table shows the relatively small effect a change in wheel diameter has on the p_{max}/f_y ratio and the significant effect of an increased rail yield strength.

If we keep the ratio below 2.0, damage to the rail head due to excessive shear stresses is unlikely. Rail life in this case would be dependent on wear considerations only.

When the ratio is between 2.0 and 3.0, premature failure of the rail head can be expected and will dictate rail life at high tonnage levels.

If the ratio is greater than 3.0, total plasticity takes place and the contact pressure is no longer dependent on wheel load.

The AAR-recommended wheel loads result in a p_{max}/f_y ratio of 2.74 on standard rail, and ratios of a similar magnitude apply to most of the mineral railways. If, however, a rail with yield strength of 115,000 psi is used, the ratio drops to 1.91 which is below the critical value of about 2.0. The 75,000-psi yield strength rail on all the railways listed is showing marked degradation of the rail head.

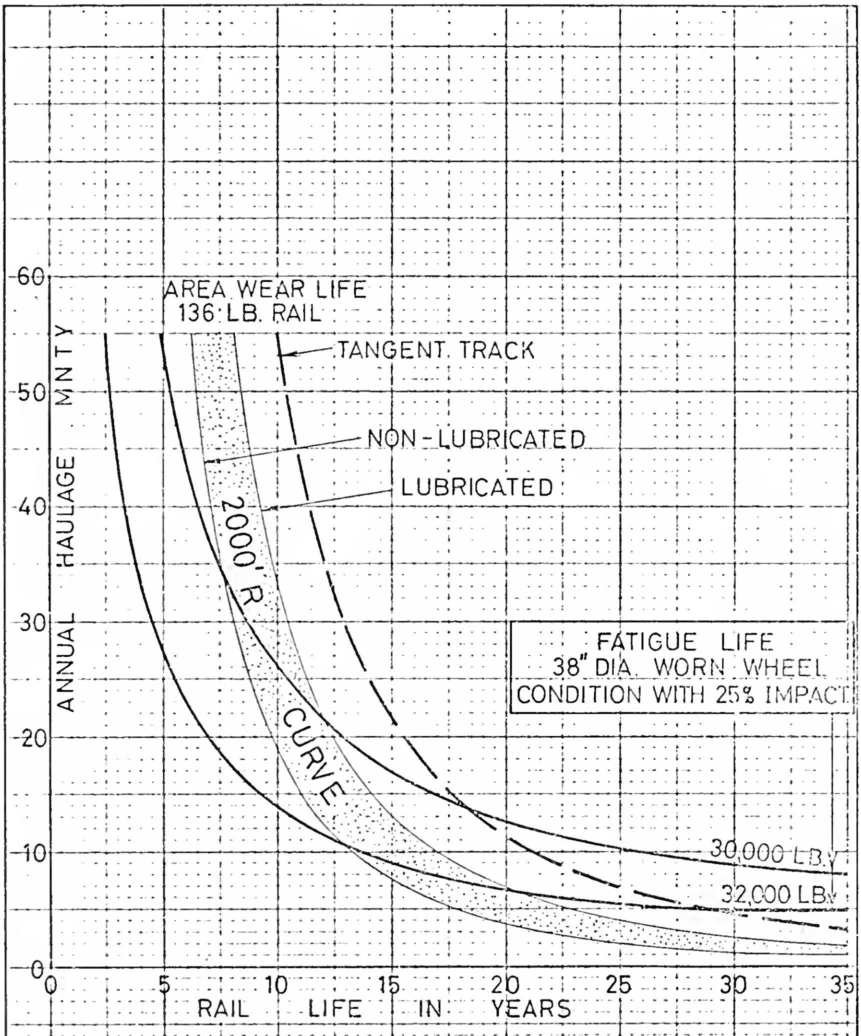
The Paradox of Rail Lubrication and Surface Hardening

While on the subject of fatigue I must make a few comments on rail lubrication and surface hardening. Unless rail life is dictated by wear criteria only, lubrication is undesirable. This is because the elimination of "natural" rail wear causes the maximum repetitive shear stress always to occur at the same point in the rail head, while if the rail was allowed to wear, the zones of maximum shear stress would become progressively deeper and ameliorate damaging fatigue effects. As proof of this, it is typical that "shelling" occurs mainly in curves where the rail is liberally lubricated and does not wear.

Fig. 7 shows rail wear life for a 2000-ft-radius curve both lubricated and nonlubricated, together with fatigue life of the rail under the action of a 32,000-lb and a 30,000-lb wheel load.

It can be seen that if the annual tonnage is high, rail life is dictated by fatigue considerations and lubricating the rail will reduce life. Greater life can be achieved by allowing natural wear to take place. If on the other hand annual tonnage is low, rail life is dictated by wear considerations and lubrication of the rail will extend rail life.

For the same reason surface hardening of the rail head through work hardening or heat treatment can reduce rail life, unless the depth of hardening is sufficient to increase the yield strength of the steel at the point of maximum shear.



RAIL LIFE ON CURVED TRACK

FIG. 7

In this context the grinding of rails to eliminate corrugations has the important secondary effect of progressively lowering the point of maximum shear stress in the rail head thereby extending fatigue life of the rail.

Thus we have the paradox that on high tonnage railways, the indiscriminate use of rail and flange lubricators or surface hardening of the rail can have the effect of actually reducing rail life.

Cost Effect of Reducing Wheel Loads

In the area of the fatigue curve where a small reduction in maximum shear stress causes a large increase in fatigue life, a reduction in wagon wheel load will increase the rail life substantially.

A few quick calculations will show that if we reduce the wheel load of a wagon from 32,000 lb to 30,000 lb, a significant saving in rerailing costs will result at the expense of additional capital costs for rolling stock.

Fig. 8 indicates the approximate return on additional invested capital through savings in rerailing, at current prices.

Cost Effect of Higher Yield Strength Rail

The experience of those high-tonnage railway systems which have used higher yield strength rail suggests an increased rail life of 2.5 to 3 times that of standard carbon steel rail. On the assumption that rail life for the high-strength rail is twice that of standard carbon rail and assuming a cost of 60% greater, the economic advantages of using a higher strength rail are clearly indicated in Fig. 8.

Conclusion

Over the past decade mineral traffic has grown to such an extent that on most railway systems in Australia it is now the predominant commodity. Associated with this boom in mineral traffic is the very real competitive need to run longer trains with heavier axle loads, and it is incumbent on us as engineers to ensure our technology and designs keep pace with the changing demand brought about by this trend.

We must restrain ourselves from being overcautious in restricting wheel loads unnecessarily and stifling the natural competitive advantages of rail transportation. At the same time, however, we must be aware of the effects of excessively heavy wheel loads.

In the last analysis it is necessary to assess the real economic optimum by balancing the immediate cost advantages of heavier axle loads against the increased long-term costs of decreased rail life.

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FIG. 8

ECONOMIC EFFECT OF REDUCING WHEEL LOADS FROM 31,200 LB TO 30,000 LB

Annual Tonnage	Increased Capital Cost of Rolling Stock	Reduced Annual Rerailing Cost	Return on Additional Invested Capital
	$	$	%
5 MTY	250,000	-	-
10 MTY	500,000	200,000	40
20 MTY	1,000,000	710,000	71
30 MTY	1,600,000	1,280,000	80
40 MTY	2,000,000	1,560,000	78
50 MTY	2,600,000	2,170,000	83

FIG. 9

ECONOMIC EFFECT OF USING HIGH YIELD STRENGTH RAIL

(Assuming twice rail life, 31,200 lb wheel loads and cost of high yield rail is 60% greater than standard rail)

Annual Tonnage	Annual Rerailing Costs		Annual Saving	Return on Additional Capital Cost
	Standard Rail	High Yield Rail		
	$	$	$	%
5 MTY	370,000	430,000	-60,000	-3.7
10 MTY	700,000	570,000	130,000	8.1
20 MTY	1,390,000	860,000	530,000	33
30 MTY	2,080,000	1,200,000	880,000	55
40 MTY	2,600,000	1,500,000	1,100,000	69
50 MTY	3,470,000	2,000,000	1,470,000	92

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PART 1

MANUAL RECOMMENDATIONS

All the recommendations submitted by committees for adoption and publication in the 1973 Supplement to the AREA Manual for Railway Engineering and the 1973 Supplement to the AREA Portfolio of Trackwork Plans are printed in this issue of the Bulletin. These recommendations will be formally submitted for review and approval to the Special Board Committee on Publications and the AREA Board of Direction. Comments or objections by Members regarding any of these recommendations should be submitted to the Executive Manager not later than FEBRUARY 15, 1973.

Manual Recommendations

Committee 1—Roadway and Ballast

Report on Assignment 1

Roadbed

F. L. PECKOVER *(chairman, subcommittee)*, W. P. ESHBAUGH, G. W. DEBLIN, J. B. FARRIS, E. M. HARDIN, H. O. IRELAND, W. P. JONES, H. W. LEGRO, F. H. MCGUIGAN, W. G. MURPHY, J. E. NEWBY, S. R. PETTIT, P. J. SEIDEL, W. M. SNOW, W. J. SPONSELLER.

Your committee submits for adoption the following recommendations with respect to Chapter 1 of the Manual:

Delete Part 1, Roadway, pages 1–1–1 to 1–1–67, inclusive (except page 1–1–16.2 and pages 1–1–36.1 to 1–1–36.9, inclusive), substituting therefor the following Sections of new Part 1: Section 1.1—Exploration and Testing, Section 1.2—Design, and Section 1.3—Construction.

Section 1.4—Maintenance, is under preparation.

Part 1

Roadbed

FOREWORD

Since the development of soil and foundation engineering as an important branch of civil engineering during the past few decades, earth and rock have come to be treated as construction materials. They have properties which can be evaluated and they are subject to strains and failures in the same way as other building materials.

Earth and rock are different, however, from such materials as steel and concrete in one fundamental way of which the designer should always be aware: each soil and rock deposit is extremely variable and has its own characteristics which reflect its origin and the factors affecting it since. As a result, investigation and testing are uniquely important if soils and rock are to be used economically and safely in engineering work.

This Part of the Manual is prepared with recognition of the importance of geotechnical knowledge in the design, construction and maintenance of track. The subgrade is considered to be as important to track performance as the rail and ballast. Keeping this balanced point of view in mind, an engineered approach is presented for many roadbed problems rather than reference to standard practice.

The choice of available methods is given along with an evaluation of the judgment factors involved in many of the questions relating to the design and construction of new roadbed and the upgrading and maintenance of existing roadbed. Considerations such as drainage and slope stability which affect the roadbed directly but are centered outside its physical limits are included.

Because of the variety of foundation conditions which occur and their associated problems, a number of references are given. Details of methods are presented only when adequate information is hard to find elsewhere. Specialized help is advisable when a detailed appraisal of the suitability and performance of particular deposits is required.

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1.4 Maintenance (to be prepared)

1.1 EXPLORATION AND TESTING

1.1.1 GENERAL

This section describes steps required to assemble sufficient information on site conditions so that a suitable design of roadbed with cuts, slopes and drainage, can be made and construction can proceed. With some change in emphasis, the same steps can be applied to investigations for structural foundations and earthworks.

Site investigations are usually done in two phases:

(1) Preliminary—Review of information available from published sources and previous investigations, supplemented by site reconnaissance.

(2) Detailed—Collection of detailed knowledge of soil, rock and groundwater conditions by exploration and sampling, field measurements and laboratory tests.

1.1.2 PRELIMINARY EXPLORATION

1.1.2.1 Information Available

Depending on the extent of the project, geological, climatic and other information from published sources may be useful in planning exploration work and interpreting site observations. The types of such information, source and use are given in Table 1.1.1.

In developed areas, information from previous local observations may be particularly useful. Available information may include record of site exploration, wells, ground water conditions, floods, and the construction and performance of structures.

1.1.2.2 Air Photographs

Air photographs at various scales are available for most states from the U.S. Department of Agriculture. Photo mosaics can be assembled and used in intensive studies of site conditions. Photos on a large scale may be required for detailed studies and can be obtained on order.

Stereoscopic viewing of overlapping air photographs assists in recognizing landforms, landslides, general soil types, drainage and erosional features. Air photo interpretation can aid in supplementing ground observations and help in planning an appropriate site investigation program. It should be remembered that as air photos only show conditions at or near the ground surface, they cannot be used dependably to give detailed information for design.

The interpretation of air photos by experienced personnel, whose services may be warranted on certain projects, can yield a variety of useful information. Even in relatively unskilled hands, air photos are helpful in planning siding extensions, drainage, industrial developments and other projects.

1.1.2.3 Site Reconnaissance

A thorough reconnaissance of the site to assess conditions and the need for detailed exploration should be done after preliminary alignment, grades and the location of structures have been chosen from major considerations of the project. Detailed

TABLE 1.1.1

SOURCES OF SITE INFORMATION

Source	*Type of Information*	*Use*
Geological Surveys: —U. S. and States —Canada and Provinces Dept. of Mines: —Canada and Provinces	Index to geological mapping. Maps of bedrock and surface materials, topography. Bulletins, papers, etc., some including detailed maps of specific areas.	Guide to specific reports and maps. Classification and distribution of deposits. Correlations and characteristics of deposits.
Geological Society of America	Water supply papers. Maps of general geology, some special features. Bulletins, papers, etc., some including maps.	Ground water conditions and resources in specific areas. Classification and distribution of deposits. Correlation and detailed characteristics of deposits.
U. S. Dept. of Agriculture, Soil Conservation Service Canada—Dept. of Energy, Mines and Resources	Air photographs	See Article 1.1.2.2
U. S. Dept. of Agriculture, Soil Conservation Service Soil Survey Services,—Canada and Provinces	Soil maps and reports	Detailed classification of surface soils, with summary of geology.
U. S. Weather Bureau Canada—Meteorological Office, Dept. of Transport	Rainfall and temperature records	Information on drainage, weathering, frost penetration.
U. S.—Various building codes National Building Code of Canada	Building code and earthquake zone requirements	Design of structures and slopes

knowledge of the site conditions rarely affects the general location of a project but often leads to adjustments in final location to reduce construction and maintenance costs. Effective site reconnaissance requires close observation of ground surface and drainage characteristics by an experienced person. Soil and rock exposures should be examined in detail and the interrelation of different deposits, their physical characteristics and their effect on construction operations should be assessed. Factors such as slope stability, weathering and seepage can usually be evaluated in the field much better than with samples in a laboratory. A particular warning is shown by the presence of soft ground, soils which become weak when disturbed, ground water seepage and eroding earth banks. Unstable ground calls for special observations, and these are discussed in Section 1.4, Maintenance.

From reconnaissance of the site, information available from other sources and the nature of the project, a decision can be made on the need for detailed exploration. Answers will be required to questions such as:

Are excavated materials suitable for fills?
If not, where are the nearest sources of suitable borrow?
Are standard roadbed sections and slopes suitable?
What type of excavation procedures can best be used?
Can excavation and replacement of unsuitable materials be avoided?
Will instability, drainage or erosion problems influence the design?
What are foundation conditions for structures?

If the project is large or sensitive to site conditions, it will probably be advisable to retain the services of a geotechnical engineer at this stage to assist in planning the most economical construction.

1.1.3 DETAILED EXPLORATION

1.1.3.1 Fill Foundations

Fill foundations are explored so that fills may be designed to avoid failure of the subsoil or excessive settlement of the fill. For this purpose the subsoil conditions should be explored to a depth at least equal to the width of the proposed fill or to competent material.

In general the exploration of the fill foundation should be accomplished with test boring and sampling techniques. The exploration program should be governed by the kinds of materials present. In the case of sands and gravels, it is usually adequate to determine the standard penetration test resistance and obtain a description of the materials. In softer materials it is important to obtain suitable samples for laboratory tests of their shear strength characteristics; the unconfined compressive strength will generally suffice in cohesive materials. In some instances, such as unusually soft fine-grained soils, a program of vane shear testing conducted in place may be desirable to supplement the boring and sampling program. Refer to Article 1.1.4 for exploration, sampling and testing procedures.

If the alignment of a proposed fill is optional, it may be possible for comparative purposes to explore alternative locations by means of geophysical methods that can indicate the depth to bedrock or much denser materials. However, the interpretation of geophysical data requires considerable expertise and supplementary test borings, and should only be used by someone skilled in this work.

1.1.3.2 Cuts

For purposes of design the stability of cut slopes is estimated in order to choose suitable arrangements of slopes and berms. In soils this calls for suitable samples and appropriate laboratory tests to find the shear strength characteristics of the materials. This is usually not a problem in sands, as disturbed samples and standard penetration test values are adequate. In clayey or silty soils, however, it may be necessary to obtain undisturbed tube samples for laboratory tests which should include classification tests, natural water content and shear strength. Exploration should be carried below the bottom of the cut. This is most important for the design of stable cuts in both cohesive materials and rock.

Particular care should be taken to identify cohesionless layers that might become water-bearing in certain seasons, as these can be expected to erode backward from the face of the cut, causing local instability or build-up of excess water pressure leading to failure by lateral spreading.

The exploration program should find the level of the groundwater table and efforts should be made to find whether or not perched water tables exist. In some instances this may require rather elaborate investigation, including the installation of standpipes at selected locations.

The exploration program should provide sufficient information to classify reliably the materials likely to be encountered, particularly when some might be classified as rock excavation. If rock is encountered above grade, the rock should be cored and the cores should be carefully described (see Table 1.1.2).

If the cut is of major dimensions and predominantly in rock, it is recommended that an engineering geologist be engaged to investigate the joint patterns and the strike and dip of the area, as the joints and fractures within the rock are of primary importance in determining the most economical and suitable cut slopes.

The subsurface exploration of cut areas should also provide information on the suitability of the materials for use in adjacent fills. Procedures described in Article 1.1.3.4 may be used for this purpose. Most materials, however, can be utilized in fills with the exception of highly organic soils, distinguished visually, and soils that have a natural moisture content considerably above the optimum water content for compaction.

A knowledge of the geology of an area is useful to indicate the necessity for additional tests of a specialized nature. For example, some geological formations have swelling characteristics and should be investigated. The presence of swelling materials may be of considerable importance in the stability of cut slopes as well as in the performance of a compacted fill.

1.1.3.3 Roadbed

Natural materials forming subgrade should be explored to assess their suitability. They should be classified and tested to find water content and remolded strength with due allowance for seasonal influences.

1.1.3.4 Construction Materials of Earth and Rock

Borrow areas for earth construction materials are often investigated by augers supplemented by test pits. Relatively large samples are required for many of the tests to be performed on borrow materials, which include grain-size analysis, natural water content, and laboratory compaction tests to find the maximum dry density and optimum water content.

It is of primary importance on major projects to verify the full extent of the proposed borrow area if large quantities of materials are required. This may require test boring and sampling. Where the borrow area may be underlain by bedrock, geophysical methods may provide a convenient means of assessing the amount of available material.

Construction with select granular fill usually presents no problems because this is usually obtained from commercial sources and meets certain specifications. If pit-run gravels or sands are to be used, however, it is advisable to do grain-size tests on typical samples as a guide to the selection of proper techniques for placing these materials. For example, a pit-run gravel that contains more than about 10 percent finer than No. 200 sieve is not likely to be successfully compacted with vibratory compaction equipment.

Particular attention is required for materials to be used as backfill around structures, as the strength of the backfill is an inherent consideration of the structural design.

1.1.4 SAMPLING AND TESTING

1.1.4.1 Rock Materials

1.1.4.1.1 Sampling

Rock samples are obtained from fresh, unweathered exposures at the site or from cores recovered from borings. Both sources should be used on projects involving significant rock problems. Borings should be made by experienced drillers. Cores of at least BX size (1⅝ in.) should be recovered.

The quantity and variety of rock sampled depends on the needs of the project and the variation in type and quality of rock present. The quantity should be that required for a detailed examination and the necessary tests. Sampling of rock and gravel for ballast is described in Part 2, Ballast, this chapter.

1.1.4.1.2 Examination

Except where the rock is to be used in a broken or crushed condition it is important to note the structural characteristics of the rock formation. Details of the geometry of a rock formation are important. The strike and dip of layers, presence of joints and faults, anticlines or synclines should be noted, along with signs of porosity or seepage. Where rock stability is concerned, classification of the rock type is less important than the properties of the rock formation except where soft or layered sedimentary rocks or very heavily weathered rocks are present. General information on the overburden is also useful.

A rock formation may be described as:

Massive—when layers and joints are spaced more than 6 ft.
Blocky when joint spacing is 1 to 6 ft.
Broken —when joint spacing is less than 1 ft.
Layered—when the bonding between strata is weak.

Test borings in rock should include such information as drilling rates, water losses and groundwater levels, identification of drill cuttings, color of drilling fluid, percent recovery and length of pieces of core. Although influenced by drilling methods, the latter indicates the quality of rock.

Rock samples and cores should be examined and described by the procedure given in Table 1.1.2, keeping in mind their relation to the rock formation which is involved in the engineering problem.

On important jobs the services of an engineering geologist should be obtained to assess significant information on rock conditions and to judge whether or not the rock is subject to deterioration on exposure.

1.1.4.1.3 Testing

In planning a rock testing program, it should be remembered that although the characteristics of the rock formation, such as joints, bedding planes and faults are the

TABLE 1.1.2

TECHNICAL DESCRIPTION OF CORES OR FRESH EXPOSURES OF ROCK

Feature	*Description or Occurrence*	*Importance*
Discontinuity —type	Joints Faults Bedding planes (as in sedimentary rock) Cleavage planes (as in slates) Fractures with striations or slickensides (from past movement)	Influence permeability, strength and deformation of rock mass
—position	Closeness and orientation of joints Thickness of bedding layers Length of core pieces (also influenced by drilling techniques) Dip or angle of inclination from horizontal	Of major importance in cut slopes and tunnels
—surface	Fit of surfaces—tight or open Shape—plane, curved or irregular Texture—slick, smooth or rough	Govern amount of interlocking and apparent shearing resistance along fractures
Filling material	Properties—type, hardness, thickness, variations Origin—derived from rock by alteration, or from external source	May govern movement along discontinuities
Rock type and texture (Ref. 1, 2)	Geologic name based on mineral composition, texture and origin Size and angularity of grains, type of fracture, lustre, lamination Texture—interlocking grains cemented or laminated—foliated, preferred orientation	
Rock hardness	Relative hardness (give basis of comparison) Variations due to changes in rock type, weakened rock, weathering or decomposition products	Severe design and construction problems may arise when hardness of parts of rock mass differ radically from average value

Derived from Ref. 3

major influences in most engineering problems, most test techniques only show the characteristics of the rock specimens used. For this reason only tests with a definite use in engineering problems should be made. Typical tests are listed in Table 1.1.3.

Petrographic analysis involves the examination by a petrologist of rock samples, sometimes in the form of thin slices, under a microscope. The analysis aids in the interpretation of other tests. From the mineralogical, physical, structural and chemical characteristics of the rock material, it is often possible to predict its response to changed conditions caused by construction or exposure.

TABLE 1.1.3

TYPICAL TESTS FOR ROCK SAMPLES

Procedure	ASTM Method	Comments
Specific gravity and absorption of		
—coarse aggregate	C 127	
—fine aggregate	C 128	
Soundness of aggregates by use of sodium sulfate or magnesium sulfate	C 88	To indicate rock resistance to weathering
Resistance to abrasion by use of the Los Angeles machine of		
—large size coarse aggregate	C 535	
—small size coarse aggregate	C 131	
Petrographic examination of aggregates	C 295	See text
Compression		
—uniaxial	Special	To classify rock for strength and deformation properties. Diamond drill cores are used.
—triaxial	D 2664	To find angle of shearing resistance of weak rock material with random orientation of joints, and of material in seams and joints. Range of normal stresses occurring in field are applied.

1.1.4.2 Soil Materials

1.1.4.2.1 Sampling

Soil samples are taken from test borings or occasionally from test pits or trenches. The boring and sampling methods chosen for a site depend on their applicability to the materials present, their ability to differentiate changes in the materials, and the disturbance caused to the samples.

Bore holes may be made by auger, wash or rotary drilling. Soil sampling is commonly done with a split spoon drive sampler when disturbed samples and standard penetration test results are required, and with thin-walled tube samplers when undisturbed samples are required.

Procedures for site investigations given in Table 1.1.4 may be used as a guide. Boring and sampling methods and requirements for exploration programs are discussed in literature (Ref. 4).

1.1.4.2.2 Classification

For soil materials it is recommended that the Unified Classification System (Ref. 5 and ASTM Method D 2487T) be used with supplemental descriptions which are helpful to those not familiar with the unified terminology. Symbols, soil groups used in the system and their identification are set out in Columns 1, 2 and 3 of Table 1.2.5.

1.1.4.2.3 Testing

Standard procedures for description, classification and testing of soils are listed in Table 1.1.5.

TABLE 1.1.4

PROCEDURES FOR SITE INVESTIGATIONS

Procedure	*ASTM Method*
Surveying and sampling soils for highway subgrades	D 420T
Soil investigation and sampling by auger borings	D 1452
Diamond core drilling for site investigation	D 2113T
Penetration test and split-barrel sampling of soils	D 1586
Thin-wall tube sampling of soils	D 1587
Field vane shear test in cohesive soil	D 2573T

T means tentative method.

TABLE 1.1.5

STANDARD PROCEDURES FOR SOIL TESTING

Procedure	*ASTM Method*
Description of soils (visual–manual procedure)	D 2488T
Classification of soils for engineering purposes	D 2487T
Grain size analysis of soils	D 422
Materials finer than No. 200 sieve in mineral aggregates by washing	C 117
Moisture content of soils	D 2216
Liquid limit of soils	D 423
Plastic limit and plasticity index of soils	D 424
Unconfined compressive strength of cohesive soil	D 2166
Specific gravity of soils	D 854
One-dimensional consolidation properties of soils	D 2435T
Moisture–density relations of soils, using 5.5-lb rammer and 12-in. drop (Proctor test)	D 698T
Moisture–density relations of soils, using 10-lb rammer and 18-in. drop (modified Proctor test)	D 1557T
Density of soil in place by the rubber-balloon method	D 1556
Density of soil in place by the sand-cone method	D 2167

T means tentative method.

REFERENCES

(1) The Identification of Rock Types, U.S. Government Printing Office, Washington, rev. Nov. 1960.

(2) H. S. Zim and P. R. Schaffer, Rocks and Minerals, Golden Nature Guide Services, New York, 1957.

(3) D. U. Deere, Technical Description of Rock Cores for Engineering Purposes, from Rock Mechanics and Engineering Geology, Springer–Verlag, Vienna, 1963.

(4) Design Manual: Soil Mechanics, Foundations, and Earth Structures, Navdocks DM-7, Washington, 1962.

(5) Earth Manual, Bureau of Reclamation, Washington, 1963.

1.2 DESIGN

1.2.1 GENERAL

Surveys and pertinent tests supply data on which the location and design of roadway is based. Horizontal alignment, grades and typical sections are based on traffic considerations and topographical features with modifications as indicated by the drainage, soil and rock data. Ref. 1 and 2 are helpful with many aspects of design. Overall environmental conditions also influence the design.

For reference purposes, subjects which may require attention in the design stage but which are more commonly dealt with in maintenance operations are found in Section 1.4, Maintenance.

Such subjects include (To be prepared).

REFERENCES

(1) K. Terzaghi and R. B. Peck, Soil Mechanics in Engineering Practice, Wiley & Sons, New York, 2nd ed. 1967.

(2) Foundation Engineering, ed. by G. A. Leonards, McGraw–Hill, New York, 1962.

1.2.2 CUTS

1.2.2.1 Cuts in Rock

1.2.2.1.1 General

The design of a rock cut is based on obtaining the lowest balanced construction and maintenance cost consistent with safety. The ratio between construction and maintenance costs will vary with individual situations and should be developed for each project.

1.2.2.1.2 Assembly of Design Information

Factors determining the amount of attention which should be given to the design of a rock cut are the competence of the rock and overburden, and the depth and length of the cut.

The first steps in design are the preparation of profiles and cross sections on which are plotted data obtained during site investigation, test borings and laboratory testing, interpreted with the aid of geological maps, groundwater surveys and air photos. Most important is knowledge of the behavior of similar rock in comparable cuts.

In layered formations where dip or strike of the bedding planes is not normal to the center of the cut, it may be desirable to construct sections on the dip of the bedding planes to aid in examining the stability of the cut slope.

As the characteristics of bedrock vary greatly, often over short distances, it is fundamental for economy that the slope be fitted to the material and exposure on each side of the cut at each location. A uniform slope in one rock is not necessarily appropriate throughout the length of a cut if the condition of the rock changes.

1.2.2.1.3 Width of Base of Cut

The base width of a rock cut is determined by the total width of zones A, B and C, shown in Fig. 1.2.1 and described in Table 1.2.1. Refer also to Article 1.2.2.1.7.

Table 1.2.1

Factors Affecting Base Width of Rock Cuts

Zone	*Purpose*	*Where Provided*	*Width and Profile*
A—Roadbed zone	To provide base for ballast	Throughout cut	Standard width
B—Ditch zone	To carry run-off from watershed served and seepage entering cut	In all cuts	Ditch profile may have to be steeper than grade profile in long level cuts.
C—Optional zone	To contain material which may fall from faces of cut, and for maintenance access	With broken or rapidly weathering rocks	Of variable width depending on slope and height of cut face, size and rate of fall of fragments and desirable frequency of ditch cleaning. Primary consideration in setting width is to position toe of slope at point which will not allow falling fragments to bounce into track area. Working width required by ditch cleaning machines is important.

1.2.2.1.4 Stability of Rock Slopes

Slopes are governed by materials in the slope, and slope angles should be chosen independently even in the same cut for sound rock, weathered or shattered rock, and overburden. See Figs. 1.2.2 (a), (b), (c), and (d).

In each material the slope is governed to a major degree by bedding planes, joints which are usually perpendicular to the bedding, fracture patterns and faulting, all of which tend to make the rock perform as a number of segments rather than as a mass. The influence of each of these characteristics should be carefully assessed in analyzing the slope stability. It should be noted that the slope of such discontinuities as entered on cross sections and profiles will not necessarily show their true angle of interception with the cut slope, which should be considered in design.

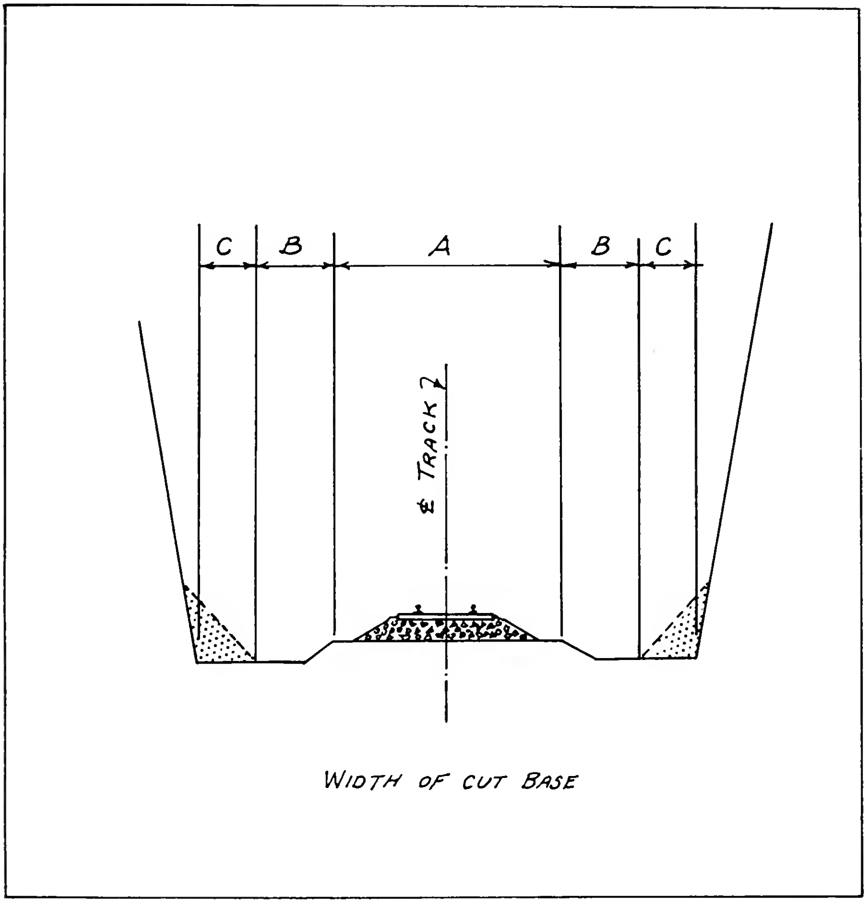


Fig. 1.2.1

Stability of rock slopes can be analyzed by the method of slices as used with soil slopes, but it should be realized that the surface of sliding will follow rock joints and defects where possible. Values of shear strength and cohesion are chosen accordingly. Cohesion in fact is usually neglected as its value along joints in rock may be small. Experience is needed to design major slopes with safety and economy.

Design factors for the more common rock conditions are discussed in Table 1.2.2. The effect of water pressures in fissures is of primary importance in all cases.

Rock falls and slides commonly occur during or soon after heavy rains, an indication of the major importance of seepage pressures on slope stability. Water has the dual effect of increasing shear stresses in the slope by its weight and hydrostatic pressure, and at the same time decreasing the shear strength of rock materials by weathering, freezing and expansion. Hence, it is most important to keep water out of the slope if possible.

In most rock masses, the ground water table cannot be lowered economically. However, intercepting surface ditches at the top or horizontal relief drains in the face or toe of slope may have benefits in certain cases (see Section 1.4, Maintenance).

TABLE 1.2.2

DESIGN FACTORS FOR ROCK SLOPES

Condition of Rock	*Design of Slope*
Hard rock with random joints	Providing there are no adverse bedding planes, ground water pressures are low and blasting is presplit, slopes of 70° are stable.
Layered rock	An accurate joint survey is important. If rock dips with the slope, and dip angle is greater than angle of friction, critical slope is at angle of dip. If bedding is horizontal, stability is as for massive rock. If bedding dips into slope, critical slope is between 70° and 90°; local rock falls may be frequent.
Fractured or weathered rocks	Stability can be analyzed as for granular soil, finding cohesion and angle of friction from lab tests. Angle of friction for angular crushed rock is 45–50°.
Clay–shale rocks	Specialist advice is required as unloaded shale tends to decrease in strength with time.

1.2.2.1.5 Effect of Blasting

Uncontrolled blasting tends to open up cracks near the face of rock slopes, allowing an increase in the rate of weathering, infiltration of water and consequent deterioration of the slope. As such blasting may produce excessive rock falls for many years, a decision on the type of blasting should be part of the design procedure. The technique of presplitting by blasting a line of drill holes on centers less than 4 ft apart can produce a slope surface with minimum disturbance and negligible overbreak. Preservation of the rock segments in their preconstruction position allows valid design assumptions to be made and minimizes ultimate maintenance costs.

1.2.2.1.6 Use of Benches

Benches in rock cuts are used to catch falling rock, to prevent undermining of hard strata by differential weathering, to reduce pressure at the toe of cut and to handle drainage. Principles applying to the choice of rock slopes and benches are illustrated in Figs. 1.2.2 (a), 1.2.2 (b), 1.2.2 (c), and 1.2.2 (d). Where permanent benches are used to intercept falling rock, as shown in Fig. 1.2.2 (c), access should be provided for periodic removal of debris. The width of such benches should be adequate for machine access after weathering of the softer rock has taken place. A minimum width of 20 to 30 ft may be required.

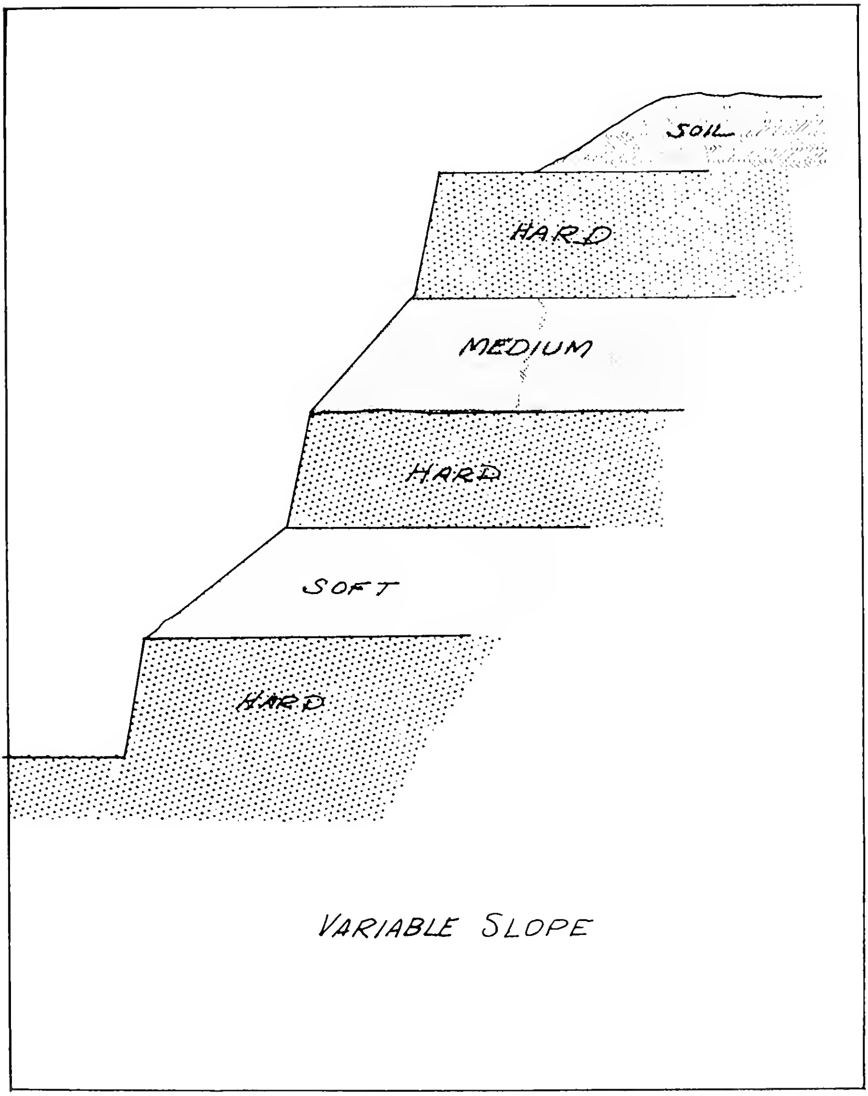


Fig. 1.2.2 (a)

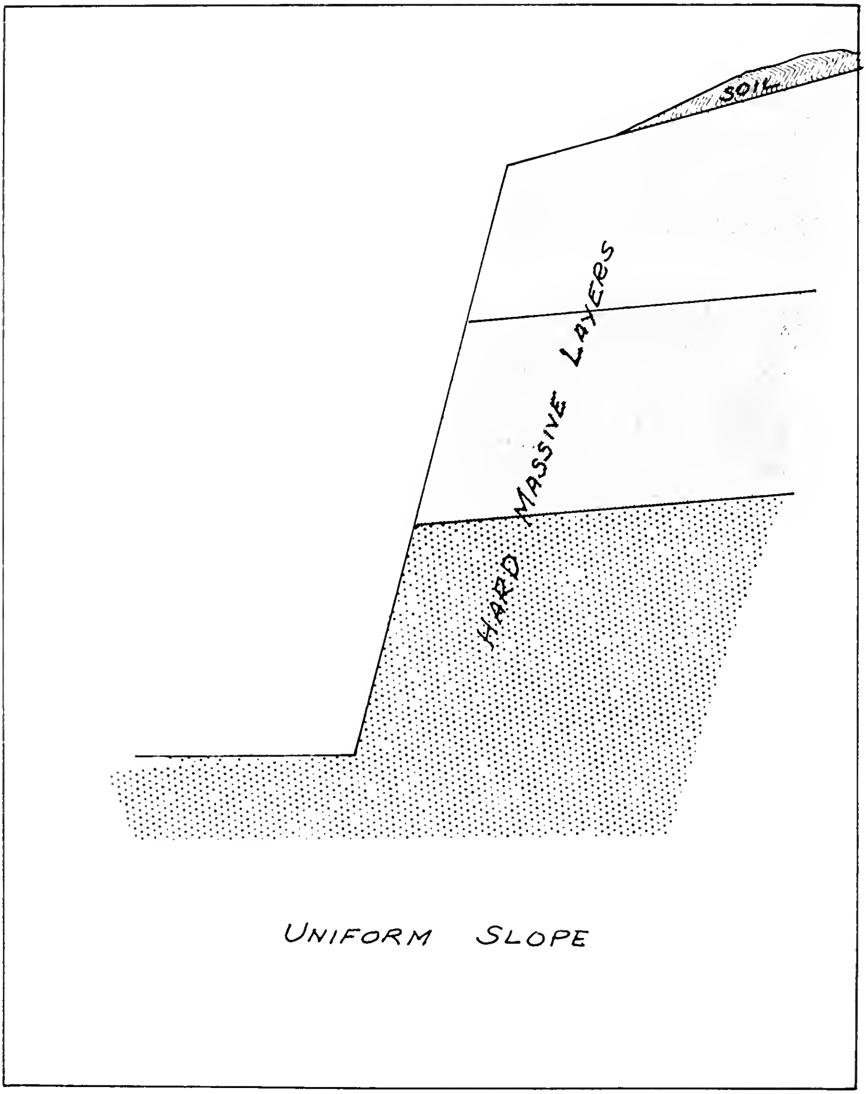


Fig. 1.2.2 (b)

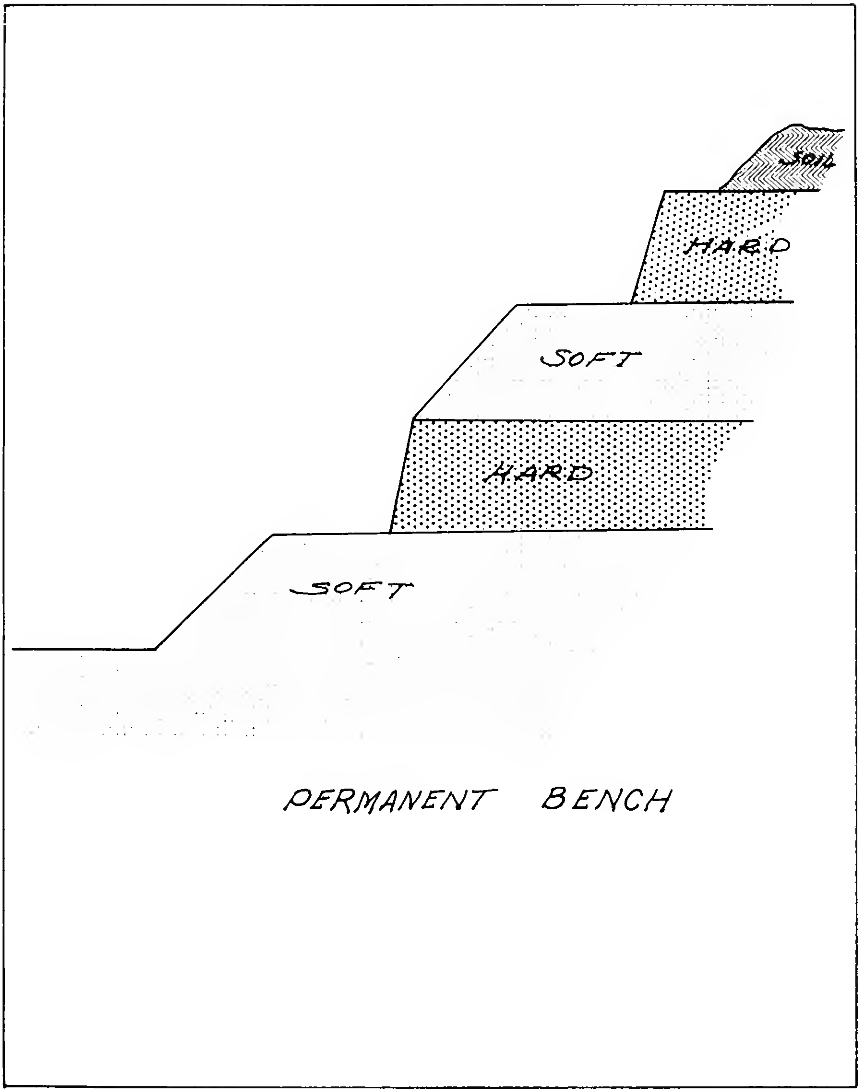


Fig. 1.2.2 (c)

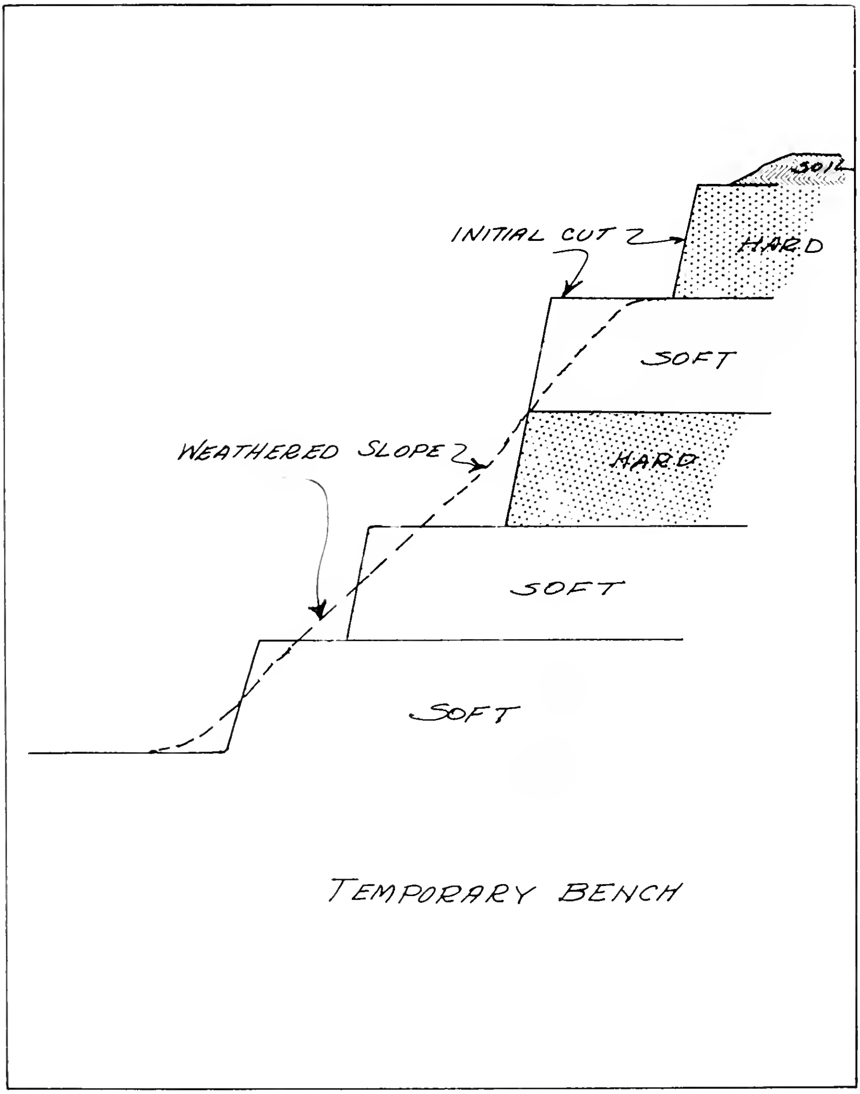

SOIL
INITIAL CUT
HARD
SOFT
HARD
WEATHERED SLOPE
SOFT
SOFT
TEMPORARY BENCH

Fig. 1.2.2 (d)

In shales and other soft-rock cuts, temporary benches may be designed to contain all debris from a steep slope.

A typical arrangement is shown in Fig. 1.2.2 (d). Debris from the top of the steep slope accumulates on the bench to form a protective zone for the toe of the slope, while the upper portion of the steep slope weathers back to its angle of repose. Provision for access to such slopes may not be required.

Benches used to reduce the effects of differential weathering are located at the top of the weaker rock where the stronger rock is set back to form the bench. The width of the bench is governed by the weathering characteristics of the weaker rock and the height and angle of its slope. Provision for access may not be required.

In deep cuts, where weaker rock appears in the base of the cut, it may be necessary to introduce benches to relieve the toe pressure. Such benches may serve other purposes, as noted above, to increase safety and reduce maintenance costs.

A permanent bench is required for accommodating longitudinal drainage from surface run-off or subsurface seepage. Such an arrangement is usually complicated and expensive and should be avoided, except in special circumstances.

Drainage of benches is best accomplished by sloping them to the face of cut, moving water off the bench as quickly as possible. Where rock on the surface of the bench presents open joints or fractures, water may be prevented from entering the rock mass by covering the bench with a layer of clay or other impervious material, thus reducing or eliminating deterioration of the rock by ice wedging and erosion.

1.2.2.1.7 Ditches and Drainage

In rockfall zones were benches cannot be provided, design of the slopes and ditches are important to prevent rock fragments from reaching the track. Falling rocks striking a slope flatter than vertical will receive a horizontal component of force tending to throw them toward the track area. For this reason, in rockfall zones the slope should be kept as nearly vertical as possible consistent with overall stability.

Unless mature cuts in similar rock can be observed, it is difficult to predict at the design stage the manner in which rocks will fall and how fast they will accumulate at the base of slope. Hence, ditches should be designed with ample width to collect rockfall material, keep it out of the track area and permit economical removal of debris. The cost of enlarging ditches later in rock cuts is prohibitive.

Measures described under Section 1.4, Maintenance, on rock slopes may be incorporated in the design stage if difficulties can be predicted.

1.2.2.2 Cuts in Soil

1.2.2.2.1 General

Soil types and drainage are the most significant influences on the design of earth slopes. All sloping ground masses have a tendency to move under the influence of gravity. Slopes of 1.5 to 1 are considered minimal in cohesionless soils and in sands or gravels with binder soils for cuts up to 20 ft deep. Observations of nearby cuts in similar soils, natural slopes in the vicinity or trial cut excavations are valuable guides in slope design. A slope stability analysis should be made to select the cross section for all cuts over 20 ft deep and where soil conditions are loose, soft, fissured or subject to seepage water pressures.

It is important that the cut cross section be wide enough to provide side ditches for interception of surface water. In addition, special conditions need to be considered, such as wide ditches for snow storage in areas of high snowfall and flat slopes to facilitate self-clearing by prevailing winds. Where it is not practical to collect surface drainage with adequate side ditches, buried drain pipes should be provided.

It is important to relieve subsurface water pressures in sloping ground by intercepting ditches or drains above the slope or horizontal drains provided in the face by drilling or excavation. In extreme cases, vertical wells can be used.

1.2.2.2.2 Cuts in Sand

Sand in any condition above the ground water table can be designed with a 1.5 to 1 slope. Dense to medium sands are normally stable on this slope even when located below the water table. In areas of loose saturated sand, special provisions are advisable to avoid spontaneous liquefaction.

The stability of slopes in sand can be increased by any technique which increases the density.

1.2.2.2.3 Cuts in Clay

Cuts in clay should be designed according to a slope stability analysis unless adequate experience locally has shown a particular profile to be stable. A slope of 2 to 1 in clay soils is considered minimum. Clay slopes over 15 ft in height should be designed on the basis of laboratory tests and stability analyses. In general the higher the slope in clays the flatter it must be for stability.

The stability of clay slopes can be increased by reducing stresses in the soil through the use of berms and drainage. As a general rule the width of berm should not be less than one-half of the vertical rise, such as a 20-ft rise with a 10-ft berm at the top followed by a second 20-ft rise. The use of berms is influenced by topography and economics. They may be desirable in deeper cuts and should be at least 10 ft wide if required for access.

Cuts in clays require caution in design. Slopes which have long been stable are known to have failed. Safety can be assured in some localities only by assuming slides as inevitable and designing the cut to allow for slope movement without interference to traffic.

1.2.2.2.4 Cuts in Non-Uniform Soils

Cuts in soils which are layered or contain pockets of varied soil types should be designed on the basis of a slope stability analysis. The coarser layers or pockets frequently are water-bearing during some part of the year and drainage must be provided. Effective drainage may stabilize the slope in a cut when soil properties are favorable.

In addition to the improvement of soil properties from drainage, berms are usually effective in increasing stability in non-uniform soil areas. Berms at the line of change of soil types allow the slope to be varied for each soil.

1.2.2.2.5 Cuts in Loess

Cuts in loess should have a near-vertical face and be carefully drained at the foot. This soil type possesses a natural cementation which is soluble, a uniform grading and a vertical root hole structure. Widths of cut greater than normal are provided since, in spite of all precautions, local failures are inevitable. Deep cuts can be made with vertical faces and berms but it is important that drainage be carefully designed and maintained.

1.2.2.2.6 Control of Slopes

In every soil type the control necessary to maintain the cut section should be a consideration in design. Berms, drainage, erosion protection, filter layers, vegetation and slope angle selection may be used. Details are given in Section 1.4, Maintenance. Cribs or retaining walls may be used in troublesome sections. Details of design are given in Chapter 8, Concrete Structures and Foundations. While slope control techniques add to costs, they will pay dividends in reduced requirements for slope restoration and ditch cleaning.

1.2.3 FILLS

1.2.3.1 General

Fills are used when it is desirable to raise the ground surface to a new level for roadbed construction. They serve to elevate the grade above existing or predicted water levels or snow depths, to bury obstructions, undesirable topographic variations or unstable subsoils and to maintain design grades.

Every fill must satisfy the following requirements:

(1) Support its own weight and superimposed loads with safety

(2) Settle not more than can be economically tolerated by the imposed loads or the fill material,

(3) Retain its shape and properties.

The requirements are met by carefully selecting the soil or rock to be used, controlling the construction and assuring an environment which prevents intolerable changes. Some fills must also function as dams and must consequently be designed to satisfy criteria of impermeability.

The volume of fill resulting from a given cut or borrow area depends on the relative in-place density of the borrow and fill materials. No standard "shrinkage factor" should be assumed. Fill materials are often compacted to a density different from their original density. On large projects it is advisable to find cut-to-fill ratios by field density tests.

1.2.3.2 Foundations of Fills

Fill foundations are subject to the basic requirements for any shallow foundations. The subsoil, or foundation soil, should have the strength to support the proposed loads, including the weight of the fill, with an adequate factor of safety and the magnitude of probable foundation settlement should be within tolerable limits. Otherwise it may be necessary to remove and replace the weak subsoil elements or to improve their characteristics by using stabilization procedures or controlled construction techniques. The latter may include compaction, construction in stages, surcharging or subdrainage.

Vegetation, topsoil and organic soils are normally removed to provide for the development of a good bond between the fill and the subsoil.

A fill underlain by a free-draining sand or gravel will have an adequate factor of safety irrespective of the fill height. The presence of a silty or clayey subsoil will call for a careful investigation of the factor of safety.

The ultimate bearing capacity of a foundation when the soil is cohesive is $\Upsilon h = 5c$

where γ = unit weight of fill material
h = height of fill
c = minimum shear strength of subsoil

Generally a factor of safety of 1.5 is considered adequate, although the need to construct a fill in an area of very unfavorable foundation soils may dictate an even smaller factor of safety. The stability is found by slope stability analysis with the critical circle or failure surface passing through the foundation.

If the stability analysis indicates an adequate factor of safety for the foundation, the fill itself is designed. When the foundation is too weak, one or more of the following procedures should be adopted to achieve a satisfactory fill:

(1) Removal or displacement of weak foundation materials,
(2) Change of the assumed fill section by flattening slopes or berming,
(3) Foundation drainage to reduce pore water pressures,
(4) Preloading the area to accelerate consolidation of clay or organic soils,
(5) Densification of sandy foundation soils.

Where feasible, the best method is removal of the unsatisfactory material by increasing the depth of initial stripping.

Berms should extend beyond the arc of the most critical failure circle and be checked for their own stability.

It is of primary importance to make a decision before construction starts on whether the fill should be floated or the foundation materials removed or displaced.

Where fills are built on soft ground or where the fill material will consolidate, an estimate of the ultimate settlement of both foundation and fill should be made and the top width of the fill increased accordingly. Peat material in foundations may be expected to consolidate under fills to about half its original thickness (Ref. 1.)

1.2.3.3 Rock Fills

1.2.3.3.1 General

Articles 1.2.3.1 and 1.2.3.2 apply to rock fills as well as earth. As with earth fills, rock fills by economic necessity are composed of materials available from cuts except in unusual circumstances where the rock is of a nature that will not support the loads placed upon it or some other unacceptable condition exists.

One such condition is the tendency of some rock fills to be subject to a long period of settlement due to the gradual consolidation of the fill itself. Where such long-term settlements cannot be tolerated, the use of select borrow or a bridge or trestle may be required. Rock fills, however, are successfully used for railway installations where settlements may be easily corrected by periodic track lifting. Many rock fills over 100 ft high have been successfully constructed and maintained, but specialists should be consulted for design and development of construction details where very high fills appear economically feasible.

1.2.3.3.2 Soft Rock

The term "soft rock" used herein refers to rock which may be excavated by power machinery without blasting or to rock which weathers rapidly upon exposure, even though blasting may be required for its initial removal.

Soft rock may result in an impervious fill and therefore must be so located in the fill cross section as to permit proper drainage. It is usually best dealt with in the same manner as earth to determine strength characteristics and compaction requirements. Slope design is best based on the results of tests, with due regard to possible softening of the rock with aging and observation of performance of similar fills constructed in past. The recommended minimum slopes for fills up to 30 ft high are 2 to 1 for impervious rock and 1.5 for pervious rock. Assistance of specialists is recommended for higher fills.

1.2.3.3.3 Hard Rock

Hard rock requires blasting for removal and is sufficiently weather-resistant to retain its strength after long exposure. Fills containing hard rock only are usually resistant to slides and are otherwise stable except that such fills often contain a high percentage of voids which cause long-term settlements. Recommended slopes are 1.5 to 1 for fills up to 50 ft high and 2 to 1 for higher fills of hard rock.

The percentage of voids and hence the settlement of a rock fill may be reduced by limiting the depth of each layer placed during construction, mixing soft rock or soil with the hard rock, compacting the fill in place, or any combination of these methods. Layers 24 to 30 in. deep are recommended with the maximum individual rock size not exceeding the layer thickness. Heavy-duty, rubber-tired rollers (50 tons or heavier) have been used to compact well-graded broken rock to 83 to 88 percent of its unit weight in the solid state.

1.2.3.3.4 Zoning of Rock

When both hard and soft rock are available to construct a fill, it is recommended that each material be located in such a position as to take advantage of and preserve its natural strength, reduce or eliminate slope erosion, provide necessary drainage and avoid trapping water within the fill.

Fig. 1.2.3 shows a cross section of a fill where the softer, weaker and less pervious rock is located in the core of the fill. The outer slope of the fill is determined by the slope needed for the weaker core material. By enveloping the core with the hard rock, the resulting slopes are strengthened, drainage is provided and the strength of the weaker material is maintained by keeping its surface from the weather. Settlement is also reduced because the softer core material may be compacted to a density more nearly to that which existed in its natural state.

Other zoning arrangements may be made, such as protecting a soft-rock core with clay soil, placing hard and soft materials in alternate layers, and mixing hard and soft materials to reduce settlement.

1.2.3.4 Selection of Soil for Fills

The quality and ease of construction of fills varies widely with different types of soil. Sands and gravels generally result in excellent bearing capacity but may require great care to compact. Silts and clays can often be conditioned or compacted to an acceptable strength, but are susceptible to freezing and changes in water content, which create maintenance problems. Fine sands, topsoils and organic soils should be rejected as fill soil. A mixture of sands and gravels with a clay binder is the most favorable soil for fill material.

The ability of various soil types to resist erosion on slopes is shown in Column 7 of Table 1.2.5. The stability of soil types in rolled fills and their compaction characteristics is shown in Columns 10 and 11 of the same Table. Methods of improving soils for use in fills are reviewed in Article 1.2.3.5.

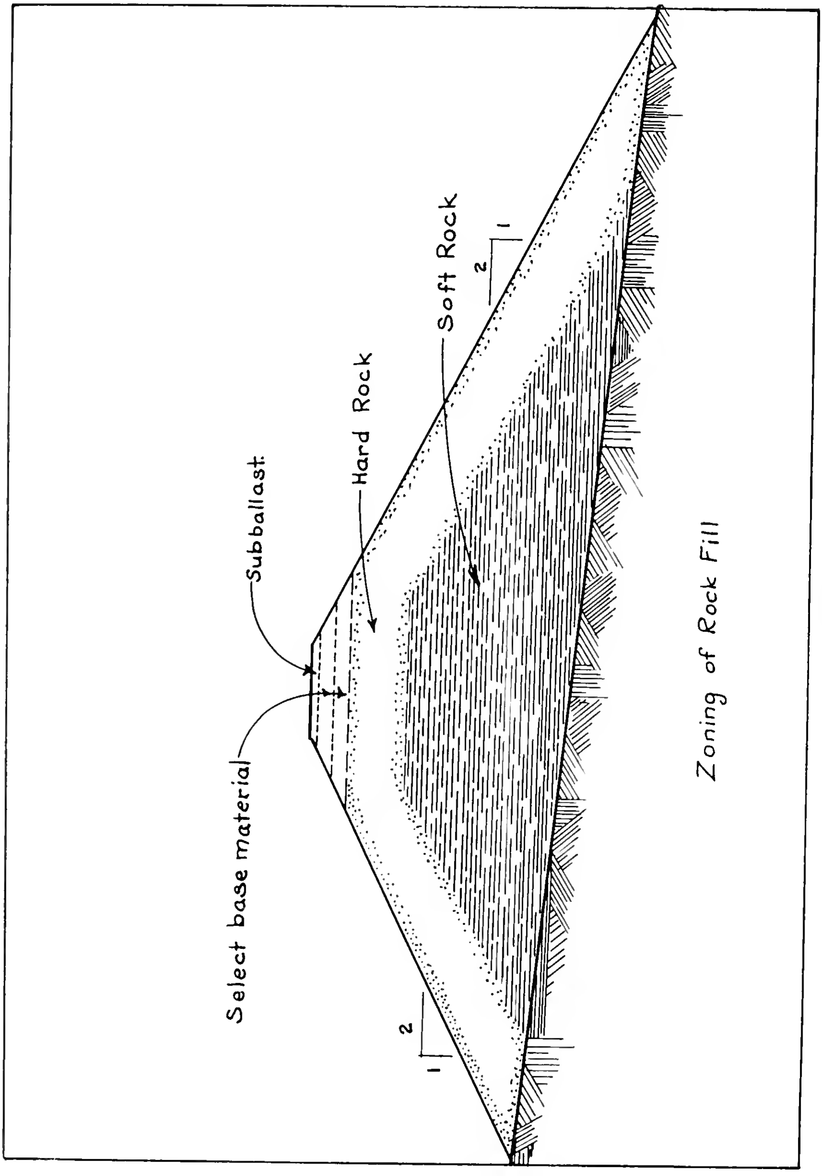

Select base material
Subballast
Hard Rock
Soft Rock
2
1
2
1
Zoning of Rock Fill

Fig. 1.2.3

The source of suitable soil is a primary factor in fill projects. Excavation, transportation and placement costs govern the final choice. Fill may be obtained from adjacent cuts, borrow areas or commercial suppliers.

1.2.3.5 Improvement of Soils

The improvement of the behavior of soil for any engineering purpose by methods which alter or control the properties of the soil is generally termed soil stabilization. There are many techniques used to create a desired property in a soil, but each has limitations as to the soil type and the minimum grain size for which it will be effective. The choice depends on the nature of the soil and the objective in improvement of it. A stabilization method or admixture should be suitable for the soil, have the required durability, provide the necessary performance economically and be practicable to the site. Table 1.2.3 categorizes the principal methods and materials.

TABLE 1.2.3

IMPROVEMENT OF SOILS

Improvement by	*Method or Admixture*	*Procedure*
Densification	Compaction	Rolling or vibrating of fill in layers with moisture control.
	*Other Methods	Vibration in depth (Vibrofloation—patented method) Compaction piles, blasting.
Drainage	Gravity Pumping *Consolidation Transpiration	Gravity removal of water. Mechanical removal of water. Surcharge loading with drainage. Planting or seeding with vegetation.
Modification	*Blending *Cement, lime, bitumen or calcium chloride	Adding select soil, mixing, compacting. Adding to soil in small quantities, mixing with moisture control, compacting, curing.

Note—Methods marked * require specialist advice.

1.2.3.6 Earth Fills

An earth fill has three basic components: a center core, shoulders or shell, and a drainage system. Homogeneous fills use the same material for the core and shoulders. Site conditions may not require special drainage provisions other than side ditches. When the fill functions as an earth dam or levee, the core is constructed of relatively impermeable material while the shell can be of any material but ideally of greater permeability than the core.

Minimum slopes with granular materials range from 1.5 to 1, and with cohesive materials from 2 to 1 for low sections to 3 to 1 and flatter for high sections. The slope for a given material should be found by a slope stability analysis.

It is important to study the effects of a new fill on the drainage of surface water. When culverts are needed to permit and control flow through a fill, the probable settlement of the fill should be considered in order to predict the required camber of the culvert and avoid a low spot.

Structures located in a fill are likely to receive a transfer of load from the fill due to settlement. If the factor of safety of the fill and its foundation is greater than 2, soil creep will generally be tolerable, and the structure can be constructed at any time with little danger of damage. If the factor of safety is less than 2, precautions should be taken to schedule construction so that the fill is built in stages with appropriate construction controls to warn of impending failure. In such cases, preferably the fill should be completed and its stability demonstrated before the structure is started. Otherwise the structure may be seriously damaged in the event of a failure. In many instances such precautions are advisable even though removal of a large portion of the previously placed fill may be required in order to erect the structure.

Procedures for placing and compacting fills are given in Section 1.3, Construction.

1.2.3.7 Sidehill Fills

The construction of a sidehill fill involves the stability of natural slopes both above and below the fill. The stability of these slopes and the fill should be analyzed separately and as a unit.

Construction procedures should be provided to prevent the fill from sliding on the original slope. The old surface should be thoroughly roughened or stepped and drainage provided to intercept water on the uphill side from seeping along the fill-slope interface.

The slopes of the fill need protection from runoff in addition to that provided at the uphill toe. Erosion protection for the slopes may be necessary, as detailed in Section 1.4, Maintenance.

Where it is not possible economically to provide an adequate factor of safety for the uphill slope, an added width of ditch or other protection should be provided on the uphill side of the fill. The fill and its loads combine to reduce the stability of the original slope. Care should be exercised to assure that excavation does not remove material below the toe of the fill which will contribute to the resistance to failure or that construction does not place a surcharge on or above the uphill slope which will increase the moving forces.

REFERENCE

(1) Muskeg Engineering Handbook, University of Toronto Press, Toronto, 1969.

1.2.4 DRAINAGE

1.2.4.1 General

This section deals with the surface and subsurface drainage of the roadway as distinguished from drainage of the ground surface by natural waterways. The latter subject is dealt with in Part 3, Natural Waterways, and Part 4, Culverts, this chapter.

Since water is the principal influence on soil stability in roadbed, subgrade and slopes, control of surface and subsurface water is one of the most important factors in roadway design and maintenance.

1.2.4.2 Surface Drainage

Surface water from the roadway area is usually handled by a system of ditches parallel to the roadbed with offtake ditches where necessary. The roadbed cross section, slopes of cuts and fills, ditches, catch basins and culverts should all form a balanced system to dispose of the water without accumulation or damaging effects.

The design capacity of any part of the system can be calculated if the quantity of water to be carried, the distance and grade to outfall and the infiltration factor of the soil is known (Ref. 1).

The ditch grade will normally be governed by the track grade, particularly in long cuts. When the ditch is constructed in earth materials the minimum grade should not be less than 0.25 percent to minimize sedimentation. Likewise to prevent erosion the maximum grade should not be greater than that which will produce a velocity shown in Table 1.2.4. Erosion may also be prevented or reduced by paving, riprapping, sodding or constructing check dams to reduce the water velocity (see Part 3, Natural Waterways this chapter).

TABLE 1.2.4

LIMITING VELOCITIES TO PREVENT EROSION

Material	*Velocity (Ft per Sec)*
Sand	Up to 2
Loam	2–3
Grass	2–3
Clay	3–5
Clay and gravel	4–5
Good sod, coarse gravel, cobbles, soft shale	4–6

Ditches may be trapezoidal or V-shaped in section. Minimum bottom width for trapezoidal ditches in earth materials is 3 ft. Side ditches should be located so that the stability of adjacent cuts and fills will be maintained. The berm between the toe of a fill and the ditch should be sloped toward the ditch for good drainage.

Wide ditches are desirable at the toe of slopes in cuts where sloughed material tends to accumulate. Wide ditches, in addition to providing storage space, also provide working space for equipment.

Ditches at the top of cut slopes to intercept runoff water from the uphill slope are often useful in reducing slope erosion or in preventing the deterioration of a rock slope due to ice formation in cracks of the rock.

The same care should be taken in designing intercepting ditches as side ditches lest they create serious erosion problems themselves. Seepage water occurring on the face of a slope may be intercepted and conducted away on benches. Benches used for drainage should be sloped back from the face and thence laterally, and should be lined if it is important to prevent infiltration.

In low-lying or flat country, it may be necessary to dig offtake ditches away from the roadway for a considerable distance to provide sufficient difference in eleva-

TABLE 1.2.5

SOIL GROUPS, THEIR CHARACTERISTICS AND USES

	(1) SYMBOL	(2) SOIL GROUP	(3) FIELD IDENTIFICATION	(4) FROST HEAVING	(5) DRAINAGE	(6) VALUE AS FILTER LAYER	(7) EROSION ON EXPOSED SLOPE
GRAVELS	GW	Well-graded GRAVELS and GRAVEL-SAND mixtures, trace to no silt or clay	Wide range in grain sizes, substantial amounts of all intermediate sizes, no dry strength	None to very slight	Excellent	Fair	None *
GRAVELS	GP	Poorly-graded GRAVELS and GRAVEL-SAND mixtures, trace to no silt or clay	Predominantly one size, or a range of sizes with some missing, no dry strength	None to very slight	Excellent	Fair to poor	None *
GRAVELS	GM	GRAVEL some SILT, GRAVEL-SAND-SILT mixtures	Fines with low or no plasticity, slight to no dry strength	Slight to medium	Fair to very poor	Very poor	None to slight
GRAVELS	GC	GRAVEL some CLAY, GRAVEL-SAND-CLAY mixtures	Plastic fines, medium to high dry strength	Slight to medium	Poor to very poor	Not to be used	None to slight
SANDS	SW	Well-graded SANDS and SAND-GRAVEL mixtures, trace to no silt or clay	Wide range in grain sizes, substantial amounts of all intermediate sizes, no dry strength	None to very slight	Excellent	Excellent	Slight to high with decreasing gravel content
SANDS	SP	Poorly-graded SANDS and SAND-GRAVEL mixtures, trace to no silt or clay	Predominantly one size, or a range of sizes with some missing, no dry strength	None to very slight	Excellent	Fair to poor	High
SANDS	SM	SAND-SILT mixtures	Fines of low to no plasticity, slight to no dry strength	Slight to high	Fair to very poor	Very poor	High
SANDS	SC	SAND-CLAY mixtures	Plastic fines, medium to high dry strength	Slight to high	Very poor	Not to be used	Slight
SILTS & CLAYS OF LOW PLASTICITY	ML	SILTS, very fine SANDS, ROCK FLOUR	Fine grained, slight to no dry strength	Medium to very high	Fair to very poor	Not to be used	Very high
SILTS & CLAYS OF LOW PLASTICITY	CL	CLAYS of low to medium plasticity, CLAY-GRAVEL-SAND-SILT mixtures	Medium to high dry strength	Medium to high	Very poor	Not to be used	None to slight
SILTS & CLAYS OF HIGH PLASTICITY	MH	SILTS, SILT-SAND mixtures of high plasticity	Slight to medium dry strength	Medium to very high	Poor to very poor	Not to be used	None to slight
SILTS & CLAYS OF HIGH PLASTICITY	CH	CLAYS of high plasticity	Sticky when wet, high dry strength	Medium	Very poor	Not to be used	None
ORGANIC	OH	Organic SILTS or CLAYS	High smell, dark colour, mottled appearance, slight to high dry strength	Medium to high	Poor to very poor	Not to be used	Variable
ORGANIC	PT	MUSKEG, PEAT	Dark colour, spongy feel and fibrous texture	Slight to high	Poor	Not to be used	Not applicable

Adapted from ASTM Method D 2487T

(8) VALUE AS SUBGRADE	(9) PUMPING ACTION	(10) STABILITY IN COMPACTED FILLS	(11) COMPACTION CHARACTERISTICS
Excellent	None	Very good	Excellent; crawler-type tractor, rubber-tired roller, steel-wheeled roller
Excellent	None	Reasonably good	Good; crawler-type tractor, rubber-tired roller, steel-wheeled roller
Good	None	Reasonably good	Good with close moisture control; rubber-tired roller, sheepfoot roller
Good	Slight	Fair	Excellent; rubber-tired roller, sheepfoot roller
Excellent	None	Very good	Excellent; crawler-type tractor, rubber-tired roller
Good	None	Reasonably good with flat slopes	Good; crawler-type tractor, rubber-tired roller
Poor	None to slight	Fair	Good with close moisture control; rubber-tired roller, sheepfoot roller
Poor	Slight	Fair	Excellent; rubber-tired roller, sheepfoot roller
Poor	Slight to bad	Poor	Poor to good with close control of moisture; rubber-tired roller, sheepfoot roller
Bad	Bad	Reasonable	Fair to good; rubber-tired roller, sheepfoot roller
Bad	Very bad	Poor	Poor to very poor; sheepfoot roller
Bad	Very bad	Fair with flat slopes	Fair to poor; sheepfoot roller
Bad	Very bad	Not to be used	Poor to very poor
Remove completely	Very bad	Not to be used	Compaction not possible

COLUMN	NOTES
2	Soil types in capitals and underlined make up more than 50% of sample. Other soil types in capitals make up more than 10%.
4	Tendency of soil to frost heave.
5	Ability of soil to drain water by gravity. Drainage ability decreases with decreasing average grain size.
6	Value of soil as filter backfill around subdrain pipes to prevent clogging with fines, and as filter layer to prevent migration of fines from below.
7	Ability of natural soil to resist erosion on an exposed slope. Soils marked * may be used to protect eroding slopes of other materials.
8	Value as stable subgrade for roadbed, when protected by suitable ballast and subballast material. Good soils may be used to protect poorer soils in subgrade
9	Tendency of soil to pump up and foul ballast under traffic.
10	Stability of soil against bulging and subsidence when used in a rolled fill. Cross check with Column (7) to forecast tendency to erode.
11	Equipment listed will usually produce the required densities with a reasonable number of passes when moisture content and thickness of lift are properly controlled.

tion to produce drainage. In such locations, sedimentation may occur requiring regular cleaning of ditches.

1.2.4.3 Subsurface Drainage

1.2.4.3.1 Importance

Only a portion of rainwater is handled by natural and man-made water-courses. The remaining water infiltrates the soil and becomes either ground water or capillary water. Where ground water is high, subsurface drainage may be needed to draw the water table down so that softening of the subgrade soils, sloughing or instability of slopes will not occur. Capillary water cannot be removed by drainage but can sometimes be controlled by lowering the water table. Lowering the water table will assist in reducing the amount of heaving track caused by frost. In such locations it is desirable to maintain the ground water table at least 4 ft below the top of subgrade.

The suitability of various soil types to gravity drainage is given in Column 5 of Table 1.2.5.

1.2.4.3.2 Types

A subdrain is any covered drain below the ground surface receiving water along its length through perforations, porous walls or joints, placed in a trench backfilled with filter material.

A rock or French drain is a trench loosely filled with stones, where water is intended to pass through the interstices of the stones instead of a pipe. Rock drains frequently plug with fines from the adjacent ground unless protected by adequate filters. For this reason they are not recommended unless properly designed and carefully installed.

Subdrains may serve as cross drains or side drains. Cross drains are laid under the roadbed or other areas to prevent water from gathering. They are placed below the level of water accumulation and connected to a side drain. Side drains are built to collect water from cross drains and to intercept water flowing toward the roadbed. A side drain may be placed at the lowest part of a seepage zone so as to collect as much of the flow of ground water as possible.

1.2.4.3.3 Design

Subdrainage pipe is available in perforated corrugated metal, rigid plastic, bituminized fiber and porous concrete. Part 4, Culverts, this chapter, gives specifications for piping and methods of installation.

Subdrainage pipe is available in diameters ranging from 2 to 24 in. Where periodic cleaning of subdrains is required, 6-in. pipe or larger is recommended. Such cleaning should not be required, however, for pipe laid at a proper gradient and surrounded with a proper filter material.

The design of subdrainage installations is made from knowledge of the depth, direction of flow and seasonal fluctuations of the ground water table. Such information is best obtained by observing the soil deposits and water levels in test pits during the wet season. The location, depth and size of pipe are chosen accordingly.

In normal subdrainage, approximately 500 ft of 6-in. intercepting drain may be used before a change to a larger size is necessary. Manholes used for cleanout purposes are usually installed at the same intervals.

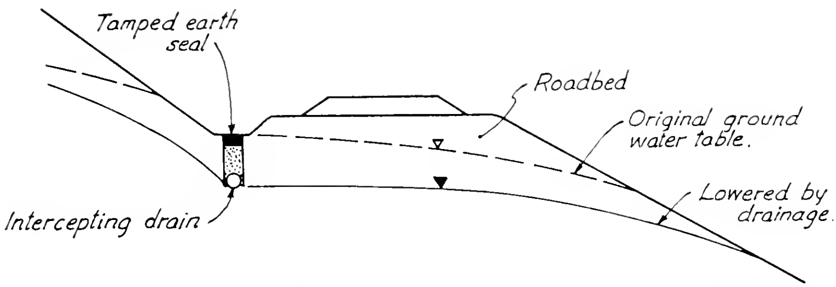


FIG. 1.2.4. INTERCEPTION OF SIDEHILL SEEPAGE BY SUBDRAINAGE.

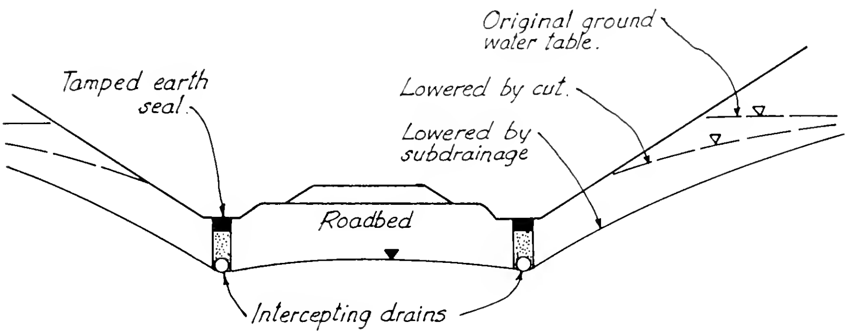


FIG. 1.2.5. LOWERING OF GROUND WATER IN A WET CUT.

A slope to ensure a velocity of 2 ft per sec should be used (see Ref. 2 and 3 for design). It is important to locate the outlet where it can be maintained free from any manner of clogging.

1.2.4.3.4 Uses

Typical uses of subdrainage installations can be illustrated by the following examples. More details are found in the references.

Sidehill Seepage Under Track—Fig. 1.2.4 shows a condition where a seepage zone tends to cause subgrade softening. After investigation by auger borings or test pits, the seepage is intercepted before it enters the roadbed area by a side drain, placed at a depth so that the effect of ground water is no longer significant.

Wet Cuts—Fig. 1.2.5 shows a condition where track maintenance is required due to the saturated condition of the subgrade. In addition to a substantial thickness of subballast, intercepting subdrains installed as shown on either side of track are necessary to stabilize subgrade.

Cut to Fill Transitions—At such locations the flow of ground water from a cut is often interrupted by cross-sloping impervious layers, causing wet conditions and soft subgrades. A subdrain placed across the roadbed may intercept the seepage, and the local use of a sub-ballast thickness greater than normal will ensure a stable subgrade.

Yard and Station Areas—Unless the subgrade soil is free-draining, a system of subdrainage will be advisable in yard and station areas, usually combined with a storm drainage system. Longitudinal subdrains between pairs of tracks with cross drains at 200- to 300-ft intervals will normally be satisfactory. Depth and spacing will depend on soil and ground water conditions.

Other Uses—Subdrains have also proven of benefit at road crossings, rail crossings and behind bridge abutments.

REFERENCES

(1) H. W. King, Handbook of Hydraulics, McGraw–Hill, New York, 3rd ed. 1939.

(2) American Iron and Steel Institute, Chicago.

(3) Concrete Pipe Design Manual, American Concrete Pipe Association, Chicago.

1.2.5 ROADBED

1.2.5.1 Design

The roadbed consists of that zone of soil or rock which supports loads from the track structure and is subject to weathering and deterioration from traffic loads.

Roadbed soils should support the loads imposed by traffic without excessive failure or deformation. To achieve this, the design of roadbed includes:

(1) Identification of the properties of the roadbed soils,

(2) Consideration of their performance in track with respect to supporting strength, tendency to foul the ballast and tendency to frost heave.

1.2.5.2 Roadbed Soils

The performance of various soil types in subgrades is indicated in Column 8 of Table 1.2.5. This applies to both cut and fill materials

The performance of plastic or cohesive soils in the roadbed may be differentiated on the basis of whether or not their plasticity index is above 10. Use of soils with a plasticity index greater than 10 for a depth of 4 ft below sub-ballast should be avoided if possible. Such materials rapidly become saturated in the roadbed, soften and, if not protected by an adequate thickness of ballast, squeeze out of place and require frequent lifting and lining of track. This type of failure is usually progressive and may become serious if axle loads are increased without a compensating increase in the thickness of ballast (see Article 1.2.5.4).

To ensure the satisfactory performance of roadbed soils it may be necessary:

(1) In fills to select or stabilize soils in the top of subgrade,

(2) In cuts to stabilize inferior soils in place or excavate and replace them,

(3) In any case to provide a graded filter layer of sub-ballast to avoid pumping of subgrade materials into ballast.

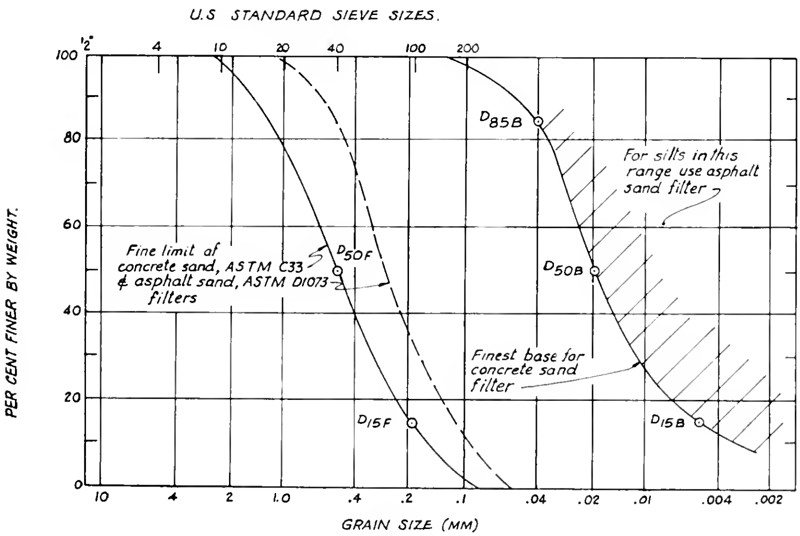
On earth-moving jobs of appreciable size there may be various types of soil present. If the most suitable soils can be selected and reserved for use in roadbed, long-term maintenance costs can be minimized at little extra construction cost.

1.2.5.3 Treatment of Roadbed Soils

If local clays are known to swell in the presence of water, or if laboratory consolidation tests on undisturbed samples show the tendency to swell, such clays should not be used in track subgrade without treatment to improve their qualities.

Clay subgrades may be stabilized by mixing with drier soils or additives such as lime or portland cement in small quantities. The use of such stabilization methods to strengthen clays in the roadbed will reduce the thickness of sub-ballast required. Stabilization methods are reviewed in Article 1.2.3.5.

Under saturated conditions and repetitive traffic loads, fine-grained subgrade materials may pump and fill the voids of ballast or sub-ballast. The tendency of various soil types to do this is indicated in Column 9 of Table 1.2.5. Pumping can be controlled by designing the sub-ballast as a graded filter layer to prevent migration of the subgrade particles. The most useful standardized gradings for filter purposes are those for asphalt and concrete sand. They are plotted and their applicability shown in Fig. 1.2.6. The figure also gives the criteria for designing filter layers for any base material. Some natural soils will serve as filters as shown in Column 6 of Table 1.2.5.



FILTER DESIGN REQUIREMENTS : F = FILTER B = BASE

1. To avoid movement of particles from base $\frac{D_{15F}}{D_{85B}} < 5$, $\frac{D_{50F}}{D_{50B}} < 25$, $\frac{D_{15F}}{D_{15B}} < 20$ (<40 For a well graded base)

2. Filter sizes - 0% > 3 IN., ≯ 5% passing no. 200 sieve

FIG. 1.2.6. GRADED FILTERS

Use of the principle of graded filter layers is most important in choosing backfill which will remain unclogged around perforated pipe subdrains and in all other locations where two adjacent materials are to remain unmixed.

An alternate means of separating two adjacent layers and at the same time preventing saturation of the lower one is by means of waterproof plastic membranes. As the membrane prevents natural evaporation, however, saturation of a clay subgrade may eventually occur in any case. For this reason use of buried membranes is only suggested where it is wished to prevent surface water from penetrating the subgrade. Neoprene film of 1/16 in. thickness is recommended for the purpose.

1.2.5.4 Ballast Thickness

To give proper support to ties in a main-line track a minimum of 12 in. of top ballast under ties and 6 in. of sub-ballast should be provided. To spread the load to subgrade, however, a greater combined thickness of ballast and sub-ballast may be needed depending on the strength of the subgrade soil. This required thickness may vary over the length of a railway line, depending on variations in the subgrade strength.

Prediction of the design strength of a roadbed soil should be based on laboratory testing of saturated remolded samples. If the same soil is in use in a railway roadbed in similar conditions elsewhere, the design strength should be found from in-place strength tests.

The design strength of subgrade should not be exceeded by the traffic loads to be applied, distributed through the rail, ties, and ballast. The load distribution may be estimated on the basis of Talbot's work (Ref. 1) and a factor of safety of 1.5 or greater depending on the frequency of traffic expected. This analysis will give a first approach to finding the combined thickness of ballast and sub-ballast required for a given axle load and subgrade strength. Judgment from experience should then be applied to choose a final design thickness.

When select soils are to be placed at the top of a fill or after sub-excavation in a cut, or when subgrade soils are to be stabilized, the above analysis will assist in deciding the economic depth of treatment required.

In the same way when axle loads or frequency of traffic is to be increased on an existing track, the analysis is useful in helping to predict how much more ballast is required to avoid subgrade failure. In this instance the design should be based on the in-place strength of the saturated roadbed soils.

1.2.5.5 Frost Heaving

To reduce maintenance costs, frost-heaving soils should not be left in the subgrade within a depth of about 60 percent of the depth of frost penetration.

Frost heaving is caused by the growth of ice layers fed by a flow of moisture from below. In general, four conditions must be satisfied for the formation of ice lenses:

(a) Capillary saturation of the soil,
(b) A free supply of water,
(c) 3 to 10 percent of soil grains smaller than 0.02 mm,
(d) A decrease in soil temperatures to below freezing.

Presumably, if any of these conditions is missing, frost heaving will not occur. Since factors (a) (b) and (d) are difficult to control, the most expedient procedure is to avoid use of soils having 3 to 10 percent smaller than 0.02 mm in grain size. The tendency of various soils to frost heave is shown in Column 4 of Table 1.2.5.

Where frost-heaving soils predominate on a site, it may be possible to minimize frost heaving by introducing a coarser layer to break the capillary rise of water within the depth of frost penetration.

If undesirable frost heaving occurs under the track, methods of dealing with it are given in Section 1.4, Maintenance.

1.2.5.6 Roadbed Dimensions

When horizontal and vertical alignment and depth of ballast are known, the width of roadbed can be chosen. Although the width can often be standardized over the length of a new line, track shoulders should be wider on fills resting on foundations which will settle. The width chosen should be based on an estimate of the ultimate settlement of both foundation and fill (see Article 1.2.3.2), combined with requirements for standard ballast sections given in Part 2, Ballast, this chapter.

REFERENCE

(1) A. N. Talbot and others, Transmission of Pressures in Ballast, Part 5, 2nd Progress Report, Special Committee on Stresses in Railway Track, AREA Proc. Vol. 21, 1920, pp. 765–814.

1.3 CONSTRUCTION

1.3.1 GENERAL

This section consists of specifications for clearing and grubbing, excavation and grading, placing of subballast material, and mulching and seeding for railway construction. The individual specification clauses are accompanied by notes to explain and limit their application. These notes are shown in italics.

The specifications are intended as a reference from which suitable requirements for a particular contract can be chosen by striking out clauses and making specific additions where required. For this reason the clauses are detailed enough to apply to large contracts but capable of being considerably shortened for small contracts.

General conditions governing construction work are found in Chapter 20, Contract Forms, Part 1, Construction Agreements.

1.3.2 DRAWINGS

Contract drawings should be prepared to suit the following requirements:

(1) A plan and profile are required showing the location of the route, identification of real estate affected, significant features of the adjacent area, existing ground levels and the level of new grade over the length of the contract. The drawing should also show road crossings, culverts, pipelines and utilities, location and water level of ponds and streams along the right-of-way, type of vegetation, and other information of use to the contractor in estimating and planning his work.

Surface outcrops of rock and presence of boulders should be shown. If either rock or soil is identified on a profile, care must be taken to give an identification correlated with more detailed information in the logs and test results. It should be noted that subsurface information shown on the profile between test pits or bore holes has been interpolated and may not conform to actual field conditions. The contractor should be required to visit the site and base his proposal and mode of operation on his own site observations.

(2) Typical cross sections of cuts and fills showing all dimensions, slopes, and classification of fill materials are required. Drainage excavations and culvert details should be shown as well as details of berms or benches, slope keying, slope drainage and blanketing, erosion protection, and stabilizing measures known to be required when the contract is tendered.

(3) Detailed logs of test pits and borings should be shown. These should be reproduced or copied directly from the report of the engineer responsible for the investigation. It is important that no simplification or interpretation of the information be attempted by those producing the contract documents. Standard terminology should always be used (see Art. 1.1.4.2.2 for example). Results of standard tests should be included.

It should be clearly stated that the information shown was obtained for the use of the railway, and that it is the responsibility of others using this information to ensure that it is suitable for their purposes and to supplement it as they consider necessary.

1.3.3 OTHER INFORMATION

It is good practice on grading contracts to include along with the contract documents a statement prepared by a geotechnical engineer describing the nature and arrangement of soil and rock deposits which will be encountered, and their possible behavior under the effects of weather variations and the disturbance of construction traffic and operations. Examples of deposits for which such statements are valuable are swelling clays, and sensitive clays which soften on remolding. Notwithstanding availability of this information, the contractor should rely on his own judgment.

1.3.4 REFERENCE SPECIFICATION FOR CLEARING AND GRUBBING

1.3.4.1 Work Included

The unit or lump sum prices submitted in the proposal shall include the entire cost of furnishing all equipment, tools, materials, and labor for clearing and grubbing the areas shown on the drawings or as required by the engineer.

All debris resulting from the clearing and grubbing operations shall be disposed of under the contractor's own arrangements, in conformance with all applicable governmental regulations.

The contractor shall note that all timber on railway right-of-way cleared becomes his property and is disposed of under his own arrangements. All such timber shall be removed from railway property well in advance of grading operations.

These clauses are subject to any other arrangements made in the purchase of the right-of-way.

Note: Paragraphs shown in italics are explanatory only.

1.3.4.2 Clearing

Clearing shall consist of the cutting of all trees, stumps, brush, shrubs, and other vegetation at a level not more than 6 inches above ground, and the disposal of all cut material and other fallen timber, fallen branches and other surface litter.

1.3.4.3 Grubbing

Grubbing shall consist of the removal and disposal of all stumps, roots and embedded logs, and all boulders and debris visible on the surface. Boulders may be disposed of within the railway right-of-way as designated by the engineer.

1.3.4.4 Procedure

Clearing and grubbing shall be done by any method which is not wasteful of earth materials required for construction purposes.

All clearing and grubbing shall be done far enough in advance of other construction operations so as not to delay them.

Trees and other growth outside the limits specified for clearing and grubbing shall be preserved and protected from damage during construction operations.

1.3.4.5 Measurement and Payment

Clearing and grubbing shall be measured and paid for by units of one acre or fraction thereof, actually cleared and grubbed, or paid for by a lump sum.

1.3.5 REFERENCE SPECIFICATION FOR EXCAVATION AND GRADING

1.3.5.1 Work Included

The unit or lump sum prices submitted in the proposal shall include the entire cost of furnishing all equipment, tools, materials and labor for stripping, excavation and grading of all classes of material, excavation for drainage, and any and all other operations necessary to complete satisfactorily the work shown on the plans and described in this specification and in accordance with the Contract Form attached.

1.3.5.2 Working Limits

The approximate working limits of this contract shall be the right-of-way from Mile .... to Mile ...., ... Subdivision, and shall include areas for borrow, waste or stockpiles, roadway, offtake ditches, and stream or river diversions which are adjacent to the right-of-way.

1.3.5.3 Quantities of Work

The quantities of work shown on the plans, proposal, etc., are approximate only and serve primarily for comparison of bids. All payments shall be made on the basis of "as constructed" quantities, at the contract unit and/or lump sum prices set out in the proposal.

1.3.5.4 Commencement of Work

No excavation or grading work shall commence until the clearing, grubbing, and prior drainage, where required, have been advanced to the satisfaction of the engineer.

1.3.5.5 Width and Shape of Excavations and Fills

The widths and slopes of all cuts and fills shall be as shown on the plans or designated in the field by the engineer.

Where necessary within the railway right-of-way, the limits of cuts may be changed on site by the engineer to provide borrow materials for fills, which will alter the dimensions shown on the plans.

1.3.5.6 Stripping

Where designated by the engineer after cross sections have been taken, areas of cuts and fills shall be stripped of all vegetation, sod, topsoil and unsuitable material which shall be disposed of or stockpiled for reuse as requested by the engineer. Such preparation in fill areas will generally be confined to areas where fill height is 4 ft or less, or where slopes to receive fill are 1 vertical to 5 horizontal or steeper. Side slopes of existing fills shall be stripped if fill is to be placed against them.

Stripping should be done wherever surface organic material will create a weak zone in the final earth mass. In addition, as organic material may frost-heave severely, it should be removed from the zone of frost penetration, the figure of 4 ft being adjusted as necessary for this purpose.

All materials removed under this Item shall be classified as "Stripping."

All stripped material suitable in the opinion of the engineer for future use on slopes to be seeded and mulched shall be stockpiled at convenient locations along the right-of-way, or as requested by the engineer.

See Art. 1.3.7 for seeding and mulching specifications.

Unless otherwise requested, stripped material shall be disposed of within the railway right-of-way as designated by the engineer. If disposal is off the railway property, the contractor shall obtain and file with the railway, prior to disposal, written permission from the owner of the property on which the material is to be placed and save the railway harmless from any claims which may arise from such disposal.

1.3.5.7 Excavation—General

The contractor will be paid only for quantities of excavation which are required for the proper completion of all work covered in this section. Additional excavation which the contractor may require for haul roads, moving his equipment, his operations and backfilling shall not be considered when establishing quantities.

All excavation areas shall be completed as far as is practical before borrow materials are obtained from outside sources.

Rainy weather may prevent prompt completion of excavation areas, but this clause is important if a contractor's price for supplying borrow material is higher than his price for excavated material.

Where fills are to be placed, ditch excavation shall be completed to the grades set by the engineer as far in advance of fill construction as practical, and maintained free of debris and other obstructions until final acceptance.

Where intercepting ditches are required at the top of slopes, they shall be excavated in advance of any adjacent cut excavation.

Ditches in cuts shall be so dug that the excavated material can be used in adjacent fills. Suitable equipment shall be used to ensure that cut slopes and subgrade sections are not undercut when excavating the ditches. Delaying the excavation of cut ditches and slope scaling until final trimming of the project is forbidden.

The contractor shall maintain all working surfaces in cuts, fills and borrow areas in a well-drained condition at all times. Surfaces shall be shaped and rolled to facilitate shedding and minimize absorption of water.

If earth surfaces are sealed by rolling with rubber-tired equipment when rain is expected, work can resume much more quickly with less need for blading off and wasting material which is too wet.

The contractor shall maintain haul routes and level off ruts in working surfaces caused by equipment.

Ruts or depressions on the surface of the subgrade will cause water pockets after train operations begin.

At no extra cost, the contractor shall supply and apply water or other means of reducing dust when required by the engineer.

1.3.5.8 Excavation in Rock

"Rock" shall include boulders 1 cu yd or larger in size and all materials considered as an integral part of bedrock which, in the opinion of the engineer, requires continuous drilling and/or blasting operations for removal. The classification of boulders as "Rock" shall be based on actual measurement only and the contractor shall give the engineer opportunity to make the required measurements.

Definitions of "Rock" and "Common Material" may need to be adjusted to suit local conditions.

The contractor shall exercise care and use suitable methods when excavating to avoid breaking down, loosening or otherwise damaging rock beyond the specified subgrade level and slope lines.

This general requirement should be replaced by particular requirements where rock strata are sloping or shattered. The effect of blasting on maintenance should be considered and the type of blasting specified (see Art. 1.2.2.1.5).

Side slopes in rock cuts may be formed by the general method of shaping them concurrently with or after the removal of material from the cut or by the method of advance presplitting rock along the required plane by blasting. If, in the opinion of the engineer, the method chosen by the contractor is not producing acceptable forming of slopes, the engineer may require a change in method. Rock beyond the line of the side slopes which is loosened by blasting, rendering it liable to slide or fall in the opinion of the engineer, shall be removed by the contractor at his expense.

Where rock materials are required for construction of fills, the contractor shall carry out blasting in such a manner that the rock will generally meet fill requirements.

Overbreak is defined as that rock loosened by construction operations beyond the specified subgrade level and slope lines. No payment shall be made for overbreak and it shall be disposed of by the contractor's own arrangement.

The bottom of rock cuts shall be excavated in such a manner that there will be free drainage without water pockets. Ditches in rock cuts shall be drilled and blasted only after the rock cut is excavated.

It is particularly important to prevent water pockets at the ends of rock cuts due to incomplete rock excavation at the junction of rock and overburden at the specified subgrade level. An alternative procedure to that specified, when the rock is suitable, is to shatter the rock in place to the level of the bottom of ditches and leave it unexcavated below subgrade level.

Where the excavation is below specified subgrade level, the roadbed shall be built up with approved fill material compacted to the correct subgrade level and width for which no additional payment will be made.

This clause is intended to minimize the amount of ballast necessary. In frost areas it is important that material approved for backfill in rock cuts be clean granular material.

1.3.5.9 Controlled Blasting of Rock

The contractor shall make all necessary arrangements satisfactory to the engineer for controlled blasting in the vicinity of the track and shall provide all safeguards required by the railway.

Within the entire area of the contract, complete and continuous precautions shall be taken by the contractor to prevent any damages to persons, vehicles, trains, power or communication lines, structures, private dwellings or other installations by reason of concussion, vibration or flying material.

The contractor shall be familiar with and comply with all regulations governing the transportation, storage, handling and use of explosives at the location of the work. He shall obtain such permits as are required.

The contractor shall take all necessary precautions against the effects of induced currents caused by radio transmitters and receivers, powerlines, transformers, cables, radar beams or any other energy or wave force which might result in premature firing of the blasting circuits.

All blasting shall be done with extreme care by experienced licensed powder men, in accordance with procedures approved by the engineer in writing.

The contractor shall submit, in advance of drilling, a drilling and loading pattern for blasting, to the engineer. All drill dust shall be blown out of the holes and holes shall be protected with suitable plugs or covers.

Approved blasting signals shall be used at all times. All blasting shall be carried out under strict traffic regulations. Each blast shall be subject to clearance by the contractor from the engineer to avoid any blasting while a train is nearby.

When necessary to protect property or facilities, all blasts shall be suitably covered with blasting mats or other approved protective material, weighted and secured in such a manner as to prevent projection of debris. The contractor is fully responsible for the method used in blasting rock and carrying out the approved procedures, and for the prompt removal of all debris deposited on track. Approval of the engineer shall not relieve the contractor in any degree whatsoever of full responsibility for damages caused by blasting operations.

1.3.5.10 Blasting by Presplitting Method

The applicability of presplitting, with its potential advantages of reduced overbreak and subsequent maintenance costs, should be judged by an experienced person in planning the project, and this Article included in the specifications if required.

Cuts to be made in rock not less than 5 ft in depth measured on the slope inclination, and where back slopes will be at least 1 vertical to ½ horizontal or steeper, shall be made by the presplitting method. In all areas designated for presplitting, the contractor, prior to the start of any drilling, shall furnish to the engineer for approval a plan of the proposed position of drill holes relative to the project centerline chainage, grade line and slope, depth of drilling, type of explosive to be used, loading pattern and sequence of firing. Approval of the plan by the engineer shall in no way relieve the contractor of responsibility for proper blasting procedures.

Holes for presplitting may be from 2½ to 3 inches in diameter. Depending on material involved, the drill holes may be spaced from 18 inches to 3 ft apart. Depth of holes shall not exceed 25 ft and shall be free of all obstructions before loading. Stemming of holes shall be with clean, dry, suitable granular material.

Presplitting shall be carried on at least 50 ft ahead of primary blasting operations. To preclude overbreak, primary blasting holes shall be located no closer than 4 ft from the presplitting line or as otherwise requested by engineer.

Only approved presplitting explosives shall be used.

Unless specifically provided elsewhere, the cost of presplitting shall be considered as included in the price paid for rock excavation. In the event of evidence that presplitting is not practicable, and in the absence of acceptable results, the engineer may in writing, waive all or part of the requirement for presplitting.

1.3.5.11 Excavation in Common Material

"Common Material" shall include all material other than "Rock" as defined herein. This shall include materials such as "hardpan", glacial till, cemented gravels, and soft and disintegrated rock which can be broken into pieces not exceeding 1 cu yd in size, by appropriate equipment, such as heavy ripping equipment.

Common material may originate from cuts, borrow areas both within and outside the railway right-of-way, ditches and any other excavations necessary for the work.

If the condition of the subgrade material in a cut is considered unsuitable by the engineer, the material shall be removed to a depth he designates and replaced with approved material compacted in accordance with the requirements of this specification.

If a uniform thickness of ballast and subballast is to be used in cuts and on fills, the supporting strength of subgrade in cuts must be made at least equal to that on fills. Backfill with clean sand and gravel is good practice in such cases.

Intercepting ditches shall be excavated behind the top of cut slopes at locations designated by the engineer to intercept water flowing into excavated areas. Excavated materials shall be disposed of on the side of the ditch toward the cut and trimmed integrally with the ditch.

Material from any excavation, including drainage ditches, not required or not approved for use in fills shall be otherwise utilized or disposed of as approved by the engineer.

Disposal of waste material may require spreading, sloping, compaction or other treatment to ensure the stability of the disposal area and its foundation. This is particularly important if the disposal area is above track grade.

When slides occur in cuts after they are properly formed, material shall be removed immediately by the contractor, the slopes modified and such other precautions adopted as approved by the engineer.

Work required to stabilize slopes may include flattening or berming of slopes, surface or subsurface drains, and blanketing with coarse granular material. Payment for such work will be negotiated between the engineer and the contractor.

1.3.5.12 Materials in Fills

Fills shall be built with approved materials from excavation and borrow areas. Roots, debris, organic material, and other unsuitable material shall not be included in fills.

The maximum size of stones or rock allowed in fills shall be the same as the maximum thickness of layer used after compaction. Oversize stones or rock shall be pushed to the side of the fill and disposed of as requested by the engineer.

No snow, ice or frozen earth shall be included in fills, nor shall fill be placed on materials incorporating snow and ice. Removal of materials required by this clause shall be at the contractor's expense.

Fully compacted railway fills may be allowed to freeze in place before the next layer is placed. With good surface drainage, ice lensing will be minimal in such cases.

Final acceptance of materials shall only be made after the materials have been dumped, spread and compacted in place. Rejection by the engineer may be made at the source, on the transportation vehicle or in place. Removal and disposal of all rejected material shall be at the contractor's expense.

1.3.5.13 Fill Material Supplied by Contractor

The contractor shall note that there may be insufficient material from excavation to complete the fills. All additional materials required shall be supplied by the contractor unless other arrangements have been made.

When the contractor is required to supply fill material from outside the railway right-of-way, he shall state on the proposal the locations from which he intends to obtain material so that the engineer can investigate the quality of material.

"Fill Material" shall be composed of "Common Material" as defined herein. In general, material such as topsoil, loam, uniform fine sand, silt, soft clay to silty clay, and other cohesive soils with a plasticity index exceeding 12 shall not be considered as fill material.

This clause may need alteration to suit local materials. The soil types named are those usually found to be unsatisfactory for fills.

At the expense of the contractor, representative samples of borrow materials will be taken by the engineer and submitted to laboratory tests for approval of its quality and nature prior to and/or during its use in the work. The contractor shall provide the necessary personnel and equipment to permit adequate investigation and sampling and shall advise the engineer at least one week in advance of the use of any material to allow sufficient time for sampling and testing.

Only approved material shall be used as fill. If in the opinion of the engineer the quality of any fill material delivered to the site is unacceptable in the light of his previous investigation, such material shall be rejected and disposed of by the contractor at his own expense.

Borrow areas shall not be excavated before they have been cross-sectioned if required by the engineer.

Borrow areas shall be adequately drained during borrow operations. Removal of earth material shall be planned to minimize erosion and saturation. Borrow areas shall be excavated to a neat and regular shape, and left in a condition satisfactory to the engineer.

1.3.5.14 Construction of Fills with Rock

Rock fill shall be placed by end-dumping or other suitable approved methods in layers not exceeding 3 ft in uncompacted thickness and extending over the full width of the fill. Each layer shall be compacted with not less than four complete passes of a crawler-type tractor weighing at least 25 tons, or with other suitable equipment in an approved manner

When rock fills exceed 50 ft in height, or the character of available rock appears to permit excessive settlement due to consolidation of the fill, the following specifications are offered for controlled compaction of the rock fills. Addition of water to rock may be specified to aid compaction.

Rock fill shall be placed in layers. The thickness of each layer shall be a function of the required final fill density and the compaction equipment used. Rock fill shall be compacted only with equipment meeting the following requirements:

(1) Heavy Vibrating Pneumatic Tired Roller
The heavy vibrating pneumatic tired roller shall be capable of producing a wheel load up to 30,000 lb and tire pressures up to 100 psi. The tires shall be mounted on two wheels abreast of each other. The roller shall produce a vibrating vertical force operating at speeds up to 1400 cycles per minute. It shall be pulled by a crawler-type tractor weighing at least 25 tons, or equivalent.

(2) Heavy Pneumatic Tired Roller
The heavy pneumatic tired roller shall be capable of producing a wheel load up to 25,000 lb and tire pressures up to 150 psi. The tires shall be mounted on 4 wheels, abreast of each other, at approximately 29 inches center to center. This roller is commonly referred to as the 50-ton pneumatic roller. It shall be pulled by a crawler-type tractor weighing at least 25 tons, or equivalent.

(3) Vibratory Compactor
The vibratory compactor shall be a drum-type roller with drums of a minimum width of 56 inches and a minimum diameter of 48 inches. The roller shall weigh 7300 to 8000 lb, have a vibrating impact of about

300 lb per inch of drum width and a frequency of 1000 to 1500 blows per minute. A suitable heavy-duty prime mover shall be used to pull the compactor.

The following table shall govern coverages and lift thicknesses. The largest size rock permitted in the fill shall have no dimension greater than the depth of lift specified. Each layer shall be bladed to a uniform loose depth before compaction.

Roller Type	*Equivalent Compaction (% of Modified Proctor)*	*Minimum Number of Coverages*	*Maximum Loose Lift Thickness (Inches)*
(1)	*90*	*2*	*18*
	95	*3*	*18*
	100	*3*	*12*
(2)	*90*	*3*	*18*
	95	*4*	*18*
	100	*4*	*12*
(3)	*90*	*4*	*12*
	95	*5*	*12*
	100	*5*	*10*

1.3.5.15 Construction of Fills with Common Material

Fills shall be built by placing common material in successive layers over the full width of the embankment. End dumping of material shall not be permitted. Where fills are designed with berms for reasons of stability, the berms must be raised at the same time as the central portion of the fill.

All earth-hauling equipment shall be routed uniformly over the entire width of fill to obtain uniform compactive effort.

Soil lumps larger than 8 inches in size shall be broken by scarifiers or disks before compaction.

Where new fill is placed against an existing slope of 1 vertical to 5 horizontal or steeper, all vegetation shall be removed, the surface deeply plowed or stepped, and the new material thoroughly mixed with the old material to a horizontal distance of 2 ft.

The thickness of each layer shall normally not exceed 8 inches before compaction. Depending on the type of fill material and the type of compacting equipment used, layers in excess of this thickness may be allowed with the specific approval of the engineer. In this case the engineer may require the contractor to perform rolling tests on the fill material to determine layer thickness and minimum number of complete passes of the compacting equipment to achieve the specified compaction.

A rolling test may normally be conducted on an initial section of fill to be incorporated into the final embankment. Hence, there is no need for extra expense. If the contractor is experienced, his proposals for layer thickness and number of passes should be used for the rolling test. At least 3 density tests should be made on each test section to compare results.

An additional rolling test should be considered whenever either fill material or compacting equipment changes throughout a project.

Each layer shall be fully compacted by approved mechanical compacting equipment before the next layer is placed. A fully compacted layer shall have a dry density of at least 95 percent of the maximum dry density as determined by the current revision of ASTM Specification, Designation D 698T, Moisture–Density Relations of Soils (Proctor Test). Material not fully compacted in fills shall be removed by the contractor at his expense when directed by the engineer.

In general, material approved for fill shall have a natural water content close to the optimum water content for compaction. The contractor shall add water uniformly by means of an approved distributor to any fill material which in the opinion of the engineer is deficient in water content for compaction. If the fill material is too wet, it shall be scarified or disked and aerated until the proper water content is attained. With the approval of the engineer, drier soil may be blended with wet fill to achieve a water content suitable for compaction.

Soil strength depends on density which in turn depends on soil water content relative to optimum water content.
A water content much below optimum will allow softening of the fill when the voids become full of rain water during a wet season after construction. A water content much above optimum will produce a soft fill and lead to shrinkage. No amount of rolling will achieve the required density when the water content is much above optimum.

All costs in supplying and applying water shall be included in the unit price for common materials.

When the specified compaction density is not being obtained, placing of additional fill shall stop and the material in place shall be scarified, adjusted in water content and re-rolled until the required compaction is obtained.

If before acceptance of the work, softening of the subgrade surface takes place under construction traffic to a degree unsatisfactory to the engineer, the soft areas shall be dug out and backfilled with the same classification of earth material in compacted layers at the required water content to obtain a satisfactory fill. The cost of all such work shall be borne by the contractor.

1.3.5.16 Compaction Equipment

At all times the contractor shall operate sufficient equipment to compact the fill at the rate at which it is being placed.

Choice of compaction equipment shall be made by the contractor and approved by the engineer. The engineer shall be the sole judge of the adequacy of any compaction equipment.

Additional materials required for the fill construction shall be supplied by the contractor at his own arrangement and expense, from sources outside the right-of-way approved by the engineer. Such fill material supplied by the contractor shall be subject to the requirements of Art. 1.3.5.13 of this specification.

All materials for fill construction shall be placed and compacted in accordance with the requirements of this specification.

Compaction equipment used shall meet the following minimum requirements:

Sheepsfoot rollers—drum 60 inch diameter, feet 8 inches long, pressure on feet 425 psi.

Pneumatic tired rollers—weight 30,000 lb or load per tire 3,000 lb; tire pressure variable from 40 to 100 psi.

Vibratory rollers—steel drum 42 inch diameter, vibrating force 300 lb per cycle per inch drum width, vibrating frequency 1,200 cycles per minute.

Other types of compaction equipment such as steel-grid rollers, steel pad rollers or heavy plate compactors may be used with the approval of the engineer.

Requirements of this clause are intended to be general, as new types of compaction equipment are marketed each year. If local materials and economics call for a restricted choice of equipment, the clause should be so worded.

1.3.5.17 Widening Existing Fills

This Article is intended to be used for the work of installing or extending fills for passing tracks, or bank widening operations.

Existing fills shall be widened to the width and slopes as shown on the plans or designated in the field by the engineer.

Suitable excavation material from cut areas, drainage ditches and side borrow within the right-of-way as shown on the plans or staked in the field by the engineer shall be used for fill construction. The contractor shall make the excavations in such a manner that waste shall be kept to a minimum. Waste material shall be disposed of as requested by the engineer at the contractor's expense.

The working area shall be maintained in a well-drained condition at all times to the satisfaction of the engineer. Drainage ditches, where required, shall be excavated in advance of borrow excavation as far as possible.

If side borrow is to be considered for use as fill material, it is particularly important that it be test pitted or sampled in advance of excavation to ensure its suitability. A layer of swampy organic material is often present and must be stripped off before suitable borrow material can be obtained.

The requirements of Art. 1.3.5.15 for placing new fill against existing slopes shall be applied.

Payment for this work shall be at the unit price for the material used.

1.3.5.18 Fills in Soft and Swampy Areas

In soft and swampy areas, designated by the engineer as not requiring subexcavation and backfill, an initial layer of material shall be placed of sufficient thickness to support earthmoving equipment.

Stabilization of the foundation or controlled construction techniques may be necessary for such conditions, requiring compaction, stage construction, surcharging or drainage (see Art. 1.2.3.2). It is of primary importance to decide before construction starts on whether a fill should be floated or the foundation materials removed or displaced.

Such a layer shall consist of granular or well graded rock material and be placed over the full foundation area of the proposed fill. Its surface shall be compacted, following which the remainder of the fill shall be built up in layers of the specified thickness.

1.3.5.19 Winter Grading with Common Materials

With the permission of the engineer, the contractor may place fills during freezing weather. For this purpose the contractor shall provide the necessary amount of earthmoving and compacting equipment to provide a continuous operation during freezing weather on both borrow and fill areas approved by the engineer. He shall control his operations to ensure that no frozen material is placed in the fills and that the material placed is completely compacted before freezing.

This item governs a practice which is in increasing use. With experience, placement of fill during temperatures down to 0 degrees F. may be done satisfactorily and at regular contract prices. Prerequisites are borrow material known to be near optimum water content (as water may not be added and drying of material in transit is minimal), and a fast-moving spread of efficient hauling and compacting equipment operating around the clock. Fill must be dug, placed and compacted in small areas.

If materials freeze before the required compaction is attained, the placing of fills shall stop and the frozen material shall be removed at the contractor's expense before filling resumes.

1.3.5.20 Field Tests

During fill placement, the engineer may perform density and other tests to control construction and may also install standpipes, settlement gauges and other apparatus to measure and observe fill performance. The contractor shall facilitate such work and shall promptly replace at his own cost any such apparatus which is damaged as a result of his operations. No claims shall be made by him for delays to his operations resulting from field tests.

If it is expected that permanent measurement installations are required, the contract documents shall so inform bidders.

During fill placement in freezing weather, density tests are best done by measuring the weight and displacement volume of chunks of frozen soil dug from the fill.

1.3.5.21 Trimming

All cuts, fills and ditches shall be left in a neatly trimmed condition to the specified widths, elevations and slopes. Borrow areas shall be excavated to a neat and regular slope to facilitate measurement of final quantities.

All waste and stockpile areas shall be left in neat, trimmed condition to the satisfaction of the engineer.

1.3.5.22 Drainage Excavation

Drainage excavation shall include all side ditches, catch water and offtake ditches, and stream or river diversions, as staked out in the field by the engineer. All ditches shall be graded so as to carry off water to the nearest natural water course with a minimum change to established drainage patterns.

Side ditches shall be located as shown on the plans or designated by the engineer.

1.3.5.23 Offtake Ditches, Stream and River Diversions

Offtake ditches shall be of the lengths, dimensions and slopes required for drainage, and as requested by the engineer. Excavated material not suitable for fill construction shall be cast out so as to leave a horizontal distance of 10 ft between the waste deposit and the top of the ditch slope.

The contractor shall make all necessary diversions of streams and rivers as requested by the engineer who will obtain any necessary permits required for such diversions. The engineer shall also arrange for any permits required for making changes in topography. To the extent required by local regulations the contractor shall conduct his operations in such manner as to preclude silt and sediment from reaching public waters.

1.3.5.24 Payment for Stripping

The unit price for "Stripping" in the proposal, per cubic yard, shall include the entire cost of stripping vegetation, sod, topsoil and unsuitable material to depths as determined by the engineer for the preparation of areas for earthwork, and disposal or stockpiling as required.

Payment shall be based on the actual volume removed within the stripped area as measured and calculated by the engineer.

Volumes will be calculated by the average end area method.

In instances of simple stripping, inclusion of pay for this item in the unit price paid for grading reduces field engineering. Payment for mucking out unsatisfactory material can be either on the unit price for grading or on an equipment rental basis as agreed in advance between the engineer and the contractor.

1.3.5.25 Payment for Rock

The unit price for "Rock" in the proposal, per cubic yard, shall include the entire cost of blasting, scaling, excavating, hauling, placing, compacting and trimming of all rockfill as specified herein.

Calculation of quantities for payment shall be made of the volume in cubic yards of rock excavated, or shattered and left in place in subgrade when required, as measured in place from the original rock surface or from the limits of other excavations to within the neat grade lines of excavation shown on the drawings or required by the engineer, complete as specified herein.

1.3.5.26 Payment for Common Material

The unit price for "Common Material" in the proposal, per cubic yard, shall include the entire cost of all excavation, ripping, hauling, placing, scarifying, blading, wetting and drying, compacting and trimming of all common materials as specified herein, including excavation of side ditches and side borrow areas within the railway right-of-way and offtake ditches outside the right-of-way.

Calculations of quantities for payment shall be based on the measurement of excavations and ditches and shall be calculated from cross-sections taken before excavation.

Materials excavated in a frozen condition and materials rejected from a fill on account of being inadequately compacted will not be paid for.

The contractor shall note that payment for all excavation will be based on material removed within the staked sections. Any ditches not meeting the staked sections shall have the quantities reduced accordingly. Materials placed in fills outside the fill sections as staked by the engineer, will be measured and deducted from the excavation pay quantities.

The unit contract prices must be understood to cover every operation necessary to complete all work connected with the excavation and grading in a workmanlike manner, all in accordance with the specifications and to the satisfaction of the engineer.

Volumes will be calculated by the average end area method.

1.3.5.27 Payment for Fill Material Supplied by Contractor

The unit price for "Fill Material" in the proposal, per cubic yard, shall include the entire cost of supplying of all additional fill material from an approved source, and shall include hauling, placing, scarifying, blading, wetting and drying, compacting and trimming as specified herein.

Quantities for payment shall be calculated from volumes of borrow areas taken before and after excavation.

Volumes will be calculated by the average end area method.

1.3.6 REFERENCE SPECIFICATION FOR PLACING OF SUBBALLAST MATERIAL

Operation of trains over track laid on new roadbed without some type of top-of-subgrade preparation such as addition of subballast or appropriate soil stabilization, tends to drive the ties into the roadbed, forming depressions which later develop into ballast pockets requiring extra maintenance. Such operation should be avoided.

1.3.6.1 General

"Subballast Material" shall meet the requirements for quality and grading set out in Part 2, Ballast, of this chapter.

Subballast material shall be placed to the cross sections and tolerances shown on the plans. Placement shall be in layers not exceeding 8 inches in uncompacted thickness.

Subballast material shall be hauled and placed by trucks or earthmoving equipment in such a way that rutting or disturbance of the completed subgrade is completely avoided. Disturbed or rutted subgrade materials shall, at the instruction of the engineer, be removed from the fill, disposed of in an approved manner and replaced, all to the satisfaction of the engineer.

Subballast material in place shall be bladed and compacted according to the requirements of Art. 1.3.5.15 or to an equivalent condition by the passage of loaded rubber-tired trucks or earthmoving equipment to a surface tolerance of ± 0.1 ft.

1.3.6.2 Payment for Placing of Subballast Material

The unit price for "Subballast Material" in the proposal, per cubic yard, shall include the entire cost of supplying, hauling, placing, blading and compacting of all subballast material as specified herein.

Payment shall be based on quantities measured and calculated in place by the engineer.

1.3.7 REFERENCE SPECIFICATION FOR SEEDING AND MULCHING

1.3.7.1 General

In general, all earth slopes and surfaces constructed under the contract shall be seeded and mulched.

1.3.7.2 Ground Preparation

The soil surface to be seeded shall be dressed to eliminate gullies on cut and fill slopes. Dressing shall be done by a drag or blades to produce a uniform surface. No plowing or disking shall be required except where construction operations have packed surfaces too hard to permit plant growth.

1.3.7.3 Seed and Fertilizer

All seed used shall be from the last available crop and shall have been tested within 5 months of the date of application. It shall be of the best grade and of known vitality, purity and germination, and shall be delivered in bags or containers bearing seed tags as required by law, showing percent of germination, purity of seed and percent of weed seed. Fertilizer shall be of standard commercial grade, with the guaranteed analysis shown on each sack. Any fertilizer which becomes caked or otherwise damaged shall be rejected.

Seed shall comply with the following specification:

Fertilizer shall comply with the following specification:

Specifications for seed and fertilizer and their rate of application should be obtained from a qualified agricultural consultant with experience in the general vicinity of the project.

1.3.7.4 Application

Seed shall be applied to take advantage of favorable weather conditions. It shall be applied hydraulically by an approved machine with seed, limestone and fertilizer mixed with water and applied at rates listed herein.

1.3.7.5 Bituminous Treated Straw Mulch

Blown bituminous treated straw mulch shall be uniformly applied over seeded areas by means of approved equipment. Bitumen shall be applied to straw as the latter is ejected from the machine. Application rates shall be not less than 1½ tons of straw and 150 gal of bitumen per acre.

1.3.7.6 Measurement and Payment

Seeding and mulching shall be measured by the acre of ground so treated.

The unit price for "Seeding and Mulching" in the proposal, per acre, shall include the entire cost of preparing the ground, furnishing, hauling and placing seed and other materials and furnishing all labor, equipment, tools and incidentals necessary to complete this work.

Report on Assignment 3

Natural Waterways

N. E. Whitney *(chairman, subcommittee)*, A. G. Altschaeffl, M. Van Kuiken, S. S. Vinton.

Your committee submits for adoption the following recommendations with respect to Chapter 1 of the Manual:

Transfer to Part 3, following page 1–3–20, the following material from Part 1:

SPECIFICATIONS FOR RIP RAP STONE, page 1–1–16.2.

CONSTRUCTION AND PROTECTION OF ROADBED ACROSS RESERVOIR AREAS, pages 1–1–36.1 to 1–1–36.9, incl.

This transfer of material is intended as a temporary measure until the revision of Part 3 is completed.

Manual Recommendations

Committee 6—Buildings

Report on Assignment 1

Buildings, Platforms, Ramps, Paving, Lighting and Other Facilities for Piggyback Terminals

G. J. Chamraz *(chairman, subcommittee)*, J. H. Adams, C. M. Diehl, J. W. Hayes, D. K. Hennessey, H. A. Shannon, Jr.

Your committee submits for adoption and publication in the Manual the following new Part 5 for Chapter 6 of the Manual.

Part 5

Design Criteria for Trailer-on-Flat-Car or Container-on-Flat-Car Facilities

5.1 TYPES OF FACILITIES

5.1.1 Circus Type Loading–Unloading

Circus type loading–unloading is recommended where a low volume of trailers is handled per day, usually less than 100, but is not necessarily limited to small facilities. It is the most economical facility to construct. The ramp can be constructed from timber, steel or concrete filled with earth on a stub-end track. Track to provide for two-directional unloading can be provided by paving an area at top of rail on which a portable type ramp may be maneuvered. (See drawings) The maximum recommended length of a tangent track is 800 ft or eight cars. The maneuvering area at the toe of a single ramp should be approximately 75 ft x 100 ft.

5.1.2 Mechanical Type Loading–Unloading

Mechanical type loading–unloading is recommended when the maximum number of trailers handled exceeds 100. Several types of mechanical equipment are available:

(a) Gantry crane, rubber-tired, spanning from one to two tracks.
(b) Rail-mounted gantry crane spanning several tracks.
(c) Side loader similar to a fork-lift truck or logging machine. This type of equipment requires substantially better paving than that required by gantry cranes.
(d) Straddle cranes for handling containers.

5.2 NUMBER OF RAIL CAR SPOTS

The number of rail car spots to be allowed for in the design of a circus type or mechanical type loading–unloading facility is determined by the volume of traffic and the availability of switching.

5.3 LIGHTING

5.3.1 Between Tracks for Circus Type Loading–Unloading

Illumination of 5 ft-c recommended at car floor height, 10 ft-c at wrench.

5.3.2 For Mechanical Equipment

For mechanical equipment, 100 ft-c are recommended, self-contained lighting.

5.3.3 General Area

(a) Parking and general track areas: 1 to 2 ft-c recommended.
(b) Maneuvering areas, trackside and ramp: 10 ft-c recommended.

5.4 POWER WRENCH OUTLETS

Power wrench outlets using electricity or air are required between tracks for circus type loading–unloading. Power wrench outlets are provided on the mechanical unloading equipment.

5.5 PLATFORMS

Between-track platforms are desirable for circus type loading–unloading facilities. Platforms should be approximately 2 ft 3 in. wide. The recommended height is 3 ft 6 in. or car floor height. Laws governing track clearances affect the width of these platforms.

5.6 PAVEMENT SYSTEMS

5.6.1 General Considerations

Two primary requirements for pavements at TOFC/COFC terminals with transfer equipment are:

(a) Capacity to support stored semi-trailers and/or containers.

(b) Capacity to support operating lifting equipment and its maximum loads.

Also desired is a low level of maintenance since closing part of a terminal for such work can seriously impair service to customers as well as cause difficult operating problems.

Economy in capital expenditures is always an important consideration, and particularly so in TOFC/COFC areas where the projected economic life of paving is short, possibly ten years or less. Some of the factors causing this are potential modifications in loading–unloading equipment that can permit the operation to be performed by one man and/or reduce if not eliminate hostling with yard tractors; variations in the trailer/container proportions; the loading or unloading of railcars carrying two tiers of containers; and the impracticality of designing a pavement with enough flexibility so that it can continue to be used in the event such changes are made.

5.6.2 Recommended Design Practice

The article in Bulletin 633 (Proceedings Vol. 73, 1972) entitled "Design of Pavements for Container Handling Areas" by F. L. Peckover and W. W. Wong and the discussion papers that followed it in Bulletin 636 should be carefully reviewed. Information should be obtained from auger borings or other methods to identify all soil strata from the surface down to a depth of about 10 ft below final grade. Ground water levels and frost depths must be determined. The drainage characteristics of the various soil types should be assessed. Where bituminous concrete surface courses are proposed, the maximum wheel loads, tire pressure, and the California Bearing Ratio of the subgrade and subbase must be found. Data needed in areas where a portland cement concrete type pavement is being considered are the maximum wheel loads, tire pressure, modulus reactions of subgrade and of subbase and the 28-day flexural strength of the concrete.

The maximum grades recommended for a semi-trailer storage area are from 0.5 to 1 percent. Steeper slopes may overcome the initial rolling resistance of trailers having landing gear supported by steel dolly wheels and parked with brakes not set.

5.6.3 Portland Cement Concrete Wearing Surface

This type of wearing surface is often used for runways for the operation of fixed path equipment, such as rubber-tired gantry cranes. Runway widths vary from 5 to 10 ft. Thickness will depend on factors given in the references in Art. 5.6.2. Reinforcement is not required if the maximum longitudinal and transverse joint spacings given in the previously cited papers are not exceeded. Outside edges, thickened 25 percent for a distance of about 6 ft inward, are recommended if the pavement is required for maneuvering of a front-loading type of vehicle. Thickened edges are unnecessary for runways for fixed path machines which are not driven off the runways except at the ends or at one or two intermediate track crossings.

Concrete pads for the semi-trailer landing gear are recommended if the landing gear on a large percentage of the trailers is equipped with steel dolly wheels instead of rectangular steel pads. Widths of from 3 to 10 ft have been used. One rule of thumb spaces the center line of the pad 10 ft from the front of the trailer parking stall.

5.6.4 Asphalt Concrete Wearing Surface

This paving is frequently used for trailer/container storage space and for truck driveway and maneuvering areas. Its thickness, and that of the underlying base and subbase layers, should be determined from the criteria mentioned in the references in Art. 5.6.2.

Where a crushed stone base course is specified, graded aggregate up to 3 in. is satisfactory. For subgrades having a CBR value above 5, or on the border between values of poor and fair, the minimum base course thicknesses for truck driveways and parking areas is 8 in., plus or minus, of crushed stone, or alternatively about 6½ in. of an asphalt concrete base mix. Over either could be applied an asphalt concrete binder course having a minimum thickness of 1½ in. followed by an asphalt concrete surface course having a minimum thickness of 1½ in.

5.6.5 Asphaltic Surface Treatment

This type of paving can be constructed where economy in initial capital expenditures is vital, yet a dust free surface is necessary. A minimum of two applications of emulsified asphalt is recommended over a 10-in. minimum thickness stone base course.

5.6.6 Waterbound Macadam

This is the least expensive type of paving. It can give satisfactory service at small- to medium-size ramp loading terminals. Dusting is a problem. Its surface will not accept parking stall or other traffic markings and the maintenance costs will be high. A minimum 10-in thickness is recommended.

5.6.7 Specifications and Construction Procedure

As pavement is an on-site constructed product, quality is dependent upon the experience, technical proficiency and equipment of the contractor. Field observations of the construction activities, and reviews of field and laboratory tests are important. These include: studying the moisture content and to determine compaction, density tests of the subgrade and of the subbase and base courses; inspection of lift thicknesses and of the uniformity of rolling; checking the joint spacing and other details of the portland cement concrete areas.

5.7 TRAILER PARKING

Trailer Parking should be provided on the basis of approximately 2½ parking spaces for each trailer handled per day. Parking stalls should be 10 ft wide and striped, using either white or yellow highway striping paint.

5.7.1 Landing Gear Pads

Portland cement concrete landing gear pads are recommended when asphaltic concrete paving is used. These should be a minimum of 10 ft wide and 8 in. thick and reinforced. However, soil conditions should govern. The center line of the landing gear pads should be 10 ft from the front of the parking stall or trailer.

5.7.2 Parking Blocks

When fencing is used, parking blocks should be located approximately 10 ft from it, giving consideration to the method of parking arrangements. Where trailers are to be cleaned, additional space should be provided for cleaning equipment between the trailer and the fence.

5.8 ACCESS ROADS

Quality paving should be provided for access roads. Convenient access to expressways and highways should be considered. The width of the access road should be a minimum of two 12-ft lanes with a minimum 5-ft shoulder on each side.

5.9 TRAILER ROOF INSPECTIONS

Trailer roof inspections, when required, are performed on trailers coming in and going out of the facility. There are several methods of making roof inspections:

(a) Overhead mirrors.
(b) High platforms with ladder or stairway
(c) TV cameras monitoring from the interior of the office building.

5.10 TRUCK SCALES

Truck scales, when required to check the weight of loaded trailers, must meet state highway specifications.

5.11 TRANSFER AND CUSTOMS INSPECTION DOCK

A transfer and customs inspection dock may be provided for transferring loads from bad order trailers and for performing customs inspections.

5.12 BUILDINGS

5.12.1 Office Buildings

The size of office buildings is determined by the number of employees and the type of facility to be served. In addition to standard office design criteria the following facilities should be considered:

(a) Parking for employees' autos

(b) Drivers' lounge

(c) Locker room

5.12.2 Car Repair Building or Facilities

Should be provided when minor car repairing is to be performed on the loading–unloading tracks.

5.12.3 Blocking and Bracing and Storage Building

Should be provided for adjusting shifted loads.

5.12.4 Trailer and Tractor Maintenance Building

May be provided when necessary.

5.12.5 Refrigerator Trailer Maintenance Building

May be provided when necessary.

5.12.6 Air Compressor Facilities

Required for making brake tests on cars and for use of air tools.

5.12.7 Interior Washing Facilities and Appurtenances

May be necessary where refrigerator trailers are handled in sufficient quantity.

5.12.8 Container Transloading Building

May be required.

5.13 FUELING FACILITY

To be considered, either gasoline and/or diesel. Equipment that would require fueling facilities:

(a) Tractors

(b) Refrigerated trailers

(c) Gantry cranes

(d) Side loaders

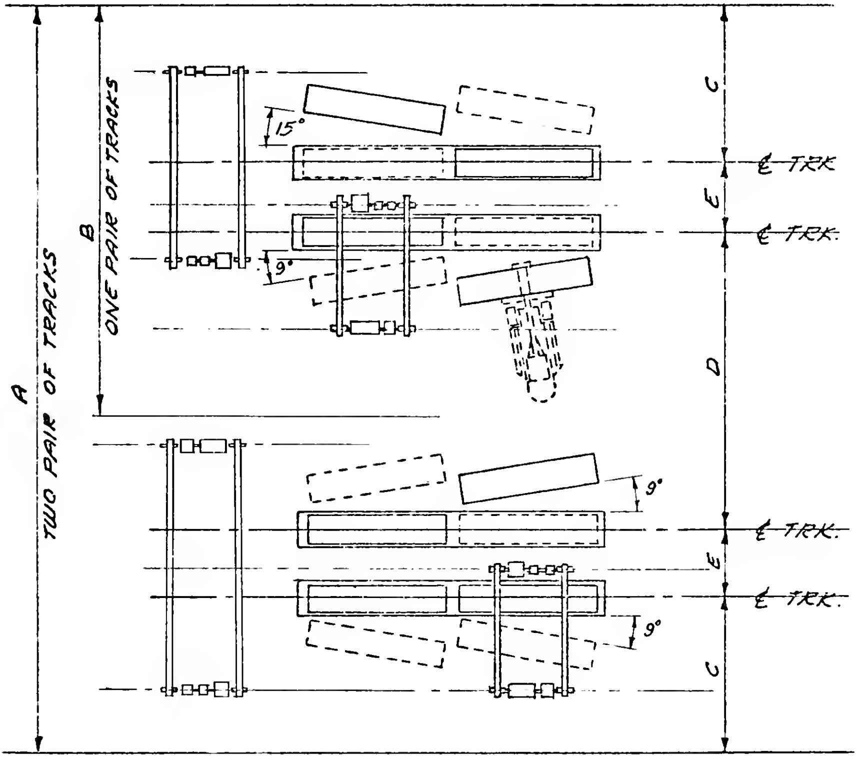
(e) Portable generators

(f) Straddle cranes

(g) Other mechanical equipment

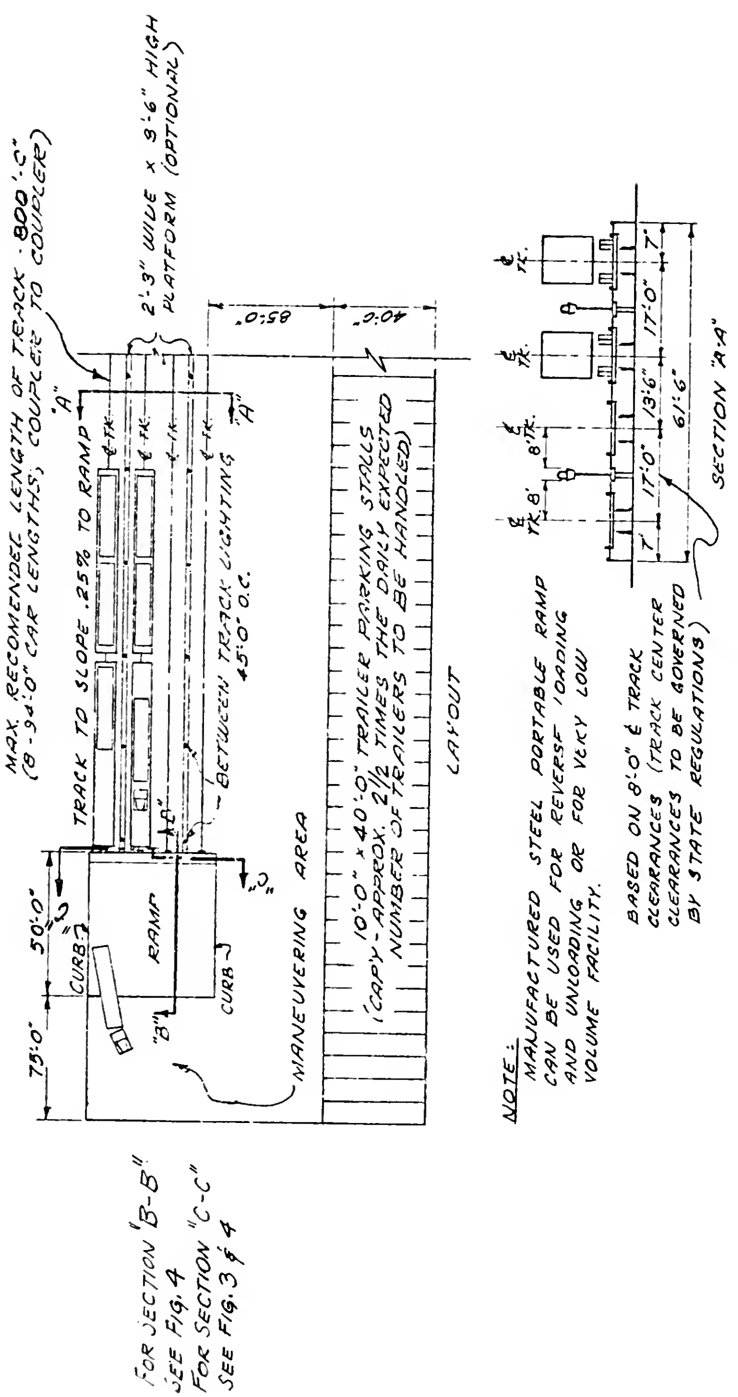
MECHANICAL DEVICE	PARKING ANGLE	A (2C+D+2E)	B (2C+E)	C	D	E	REMARK
SIDE LOADER	9°	276'	163'	71'-6"	93'	20'	
32' GANTRY	9°	196'	110'	45'	66'	20'	STRADDLING ONE TRACK AND ONE TRAIL. PARK. AISLE
40' GANTRY	9°	211'	110'	45'	81'	20'	STRADDLING ONE TRACK AND ONE TRAIL. PARK. AISLE
60' GANTRY	9°	183'	103'-6"	45'	66'	13'-6"	STRADDLING TWO TRACKS AND TWO TRAIL. PARK. AISLES
60' GANTRY	15°	233'	122'-6"	54'-6"	97'	13'-6"	STRADDLING TWO TRACKS AND ONE TRAIL. PARK. AISLE

TRACK CENTERS "E" TO BE GOVERNED BY STATE REGULATIONS



TOFC-COFC GANTRY & SIDE LOADING AND UNLOADING

FIGURE 1



END LOADING

FIGURE 2

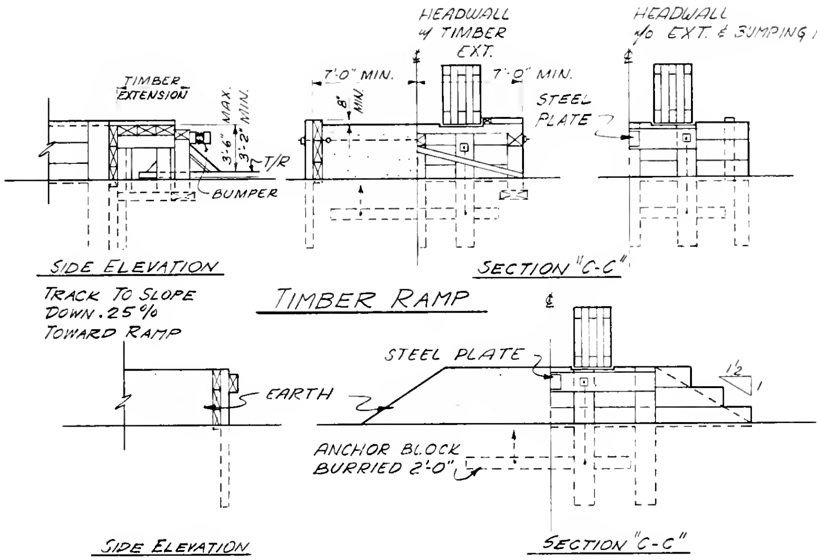


FIGURE 3

5.14 SURFACE DRAINAGE

Surface drainage should be provided where surface water run-off presents a problem. Storm sewers should be utilized where they are available. Local codes governing run-off must be followed. Where storm sewers are not available, the surface run-off may be directed to open ditches, which would drain into retention ponds of sufficient capacity.

5.15 SNOW REMOVAL

Snow removal should be provided in appropriate areas. Methods of snow removal to be given consideration are:

(a) Salting

(b) Storage at Site

(c) Removal from Site

5.16 SECURITY

Security may be necessary at some locations. Usual types of security protection are:

(a) Chain link fence, minimum height of 6 ft with three strands of barbed wire on top and bottom and top pipe rail.

(b) TV monitoring—The entire facility may be observed from within the office if cameras are properly located.

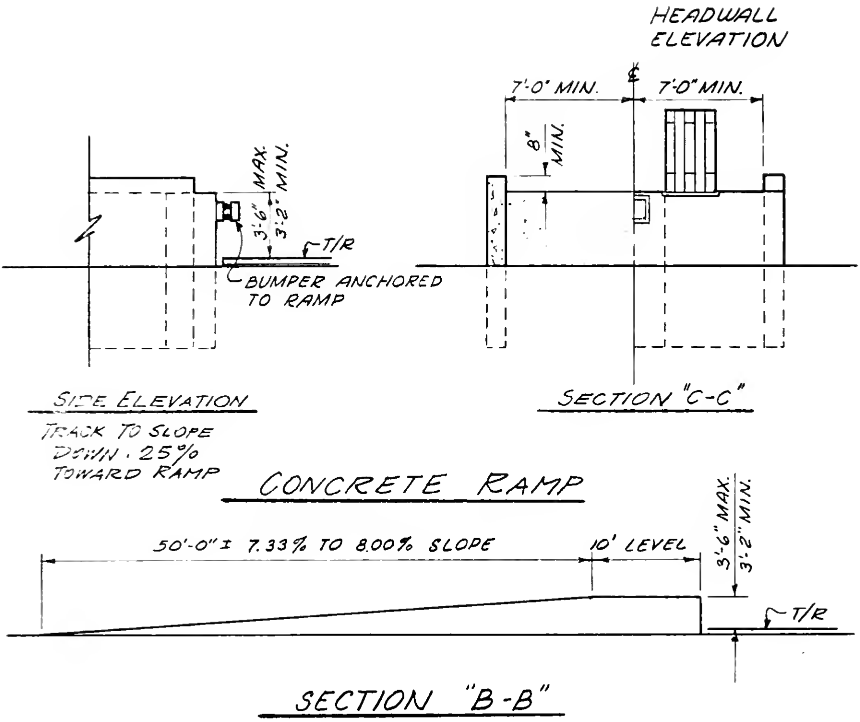


FIGURE 4

(c) Alarm systems may be installed on the fence to alert local police and authorized personnel.

(d) Flood lighting.

(e) Separate employees parking area should be provided to discourage internal pilferage.

(f) Surveillance may be provided.

5.17 POLLUTION CONTROL

Pollution control should be provided at the following servicing areas:

(a) Fueling.

(b) Maintenance building.

(c) Outside maintenance areas.

(d) Trailer and truck washing facilities.

(e) Meat hook washing facilities.

Report on Assignment 4

Design Criteria for Spot Car Repair Facilities

T. H. Seep *(chairman, subcommittee)*, E. P. Bohn, A. C. Cayou, I. G. Forbes, W. C. Humphreys, G. R. Hunt, L. S. Newman, L. J. Nichols, L. A. Palagi, J. S. Smith.

Your committee submits for adoption and publication in the Manual the following new Part 3 for Chapter 6.

Part 3

Design Criteria for Spot Car Repair Shops

3.1 FOREWORD

3.1.1 General

A spot car repair system is a facility arranged to bring cars in need of repairs to one central station, thus eliminating lost time in moving men, equipment, materials and tools to the cars. One-spot systems are designed primarily for making light repairs. It usually is advantageous to have at least one track for heavy repairs and for working on three-axle trucks. The facilities must be designed in cooperation with all departments concerned, with the architect or building engineer as the coordinator.

3.1.2 Advantages

Time studies indicate approximately 100 percent increase in efficiency over the rip-track method. This is due to all work being performed more efficiently, in a compact area, under direct supervision and protected from bad weather. Bad order delays have been reduced in some cases as much as 12 to 24 hours.

The switch engine places the cars on the inbound receiving track and picks them up on the outbound track, eliminating the spotting and uncoupling of cars. All car movement is handled by the repair personnel in the shop and equipment is interlocked against train movement through the facility.

3.2 SITE CONSIDERATIONS

3.2.1 Location

The arrangement of the yard and its operation will dictate the locations of the shop facility.

3.2.2 Parking

Parking should be provided for personnel working in the area and for visitors. Consideration should be given to overlapping shifts.

3.2.3 Landscaping

Landscaping should be provided in accordance with code requirements. Vegetation used should be easy to grow and to maintain.

3.2.4 Trackage

The track layout is dictated by trackage available and directly affects switching frequency. Inbound track should have a capacity of 20 cars (two 10-car cuts) and an outbound capacity of 10 to 15 cars. With this arrangement, the operating department has approximately 8 hours or more lead time to supply cars. Track profile must be provided for car control inbound, and free roll outbound must be provided.

Where trackage is not available more switching is required and, in some cases, the cars must be brought into the facility through switches with the use of tractors or similar devices.

Where automatic car moving equipment is used, tracks should be tangent throughout the puller area.

Track centers should not be less than 26 ft with 30 ft to 40 ft considered optimal.

3.3 BUILDING CODES

The designer should check on all applicable codes. The following list should serve as a guide:

(a) Municipal
(b) City
(c) State
(d) Sanitary
(e) Industrial Commission
(f) Electrical
(g) Mechanical
(h) Fire Regulations
(i) Board of Transport (Canada)
(j) Pollution Control Board
(k) Other

3.4 STRUCTURAL REQUIREMENTS

3.4.1 Building Types

A variety of building types will normally meet the requirements of this service. Pre-engineered steel buildings are probably the most common, followed by masonry construction and steel framing construction.

3.4.2 Structural Systems

Columns or posts between tracks reduce flexibility of operations. Rigid frames or trusses provide clear spans and are desirable, in the main shop area at least.

3.5 SPECIAL REQUIREMENTS

3.5.1 Size

(a) *Length:* Length will depend primarily on the desired number of work positions and whether end doors are used. With closed doors, a practical minimum length for a one-spot facility is 160 ft. A two-spot facility should be a minimum of 280 ft long with the jacking position located approximately 80 ft from the inbound end of building. This provides enough length to advance a repaired car ahead for testing air brakes, move a second car into jacking position and have both cars inside the building. A building with open ends needs only be long enough to cover the work area; the minimum length would be 100 ft. These figures assume the use of built-in or stationary jacking equipment.

(b) *Width:* Side of building to center line of first track should not be less than 17 ft. Track centers preferably should be 30 ft to 40 ft.

(c) *Height:* Clearance above rail in working areas should be a minimum of 25 ft. Wall height of main shop building should be such that 22 ft clear track door openings can be obtained. Offices, lunch rooms, and other areas not in main shop may be in lean-to's with ceiling heights to suit the occupancy.

3.5.2 Special Areas

(a) *Offices (Minimum Office Size):* Suitable office space should be provided for the shop foreman, his assistant and clerical staff. Offices should be designed in accordance with Part 2—Design Criteria for Railway Office Buildings, this Chapter.

(b) *Lunch and Locker Rooms:* Lunch and locker rooms are necessary for all employees and if required should be separate rooms. If both males and females are employed, separate locker rooms must be provided. Each employee must have a personal locker, thus the size of the room is based on the number of lockers. An approximate figure to use to size the room is a minimum of 10 sq ft per locker. Lunch tables should be included to provide a space for each employee based on the greatest number per shift.

(c) *Toilet Facilities:* Toilet facilities should be provided for shop forces and office personnel. If possible, shop toilet facilities, at least urinals, should be provided near the work areas to eliminate men being away from the work station for any great length of time. The number of fixtures required is a code requirement and varies with different locations.

(d) *Store Facilities:* The store department should be consulted on their space requirements which will usually consist of one large storage area complete with racks and bins, located as near as possible to the central work area of the shop. Usually also required are areas for lube pad soaking machines, oil storage, paint storage, wheel storage and a lumber store. Storage area should also be provided outside the building for items such as draft gears, couplers, brake shoes, brake beams, springs, miscellaneous steel, side frames, D. F. bars, barrels of oil, solvent, etc. This area should be surfaced with either concrete or asphalt, designed to support the wheel load of lift trucks. An unloading platform and ramp should be provided, the platform to be 3 ft 9 in above top of rail and the ramp at least 50 ft long. The size will vary; however, the platform should be large enough for the anticipated lift truck operation.

(e) *Boiler Room:* This may or may not be required depending on whether the building is to be heated and what kind of heating is to be provided.

(f) *Compressor Room:* The size of the room and air intake and exhaust will be determined by the size of the compressor to be installed. Special foundation shall be designed to support the weight and vibration of the compressor.

(g) *Tool Room:* A tool room of ample size to contain all the tools required in this facility should be included.

(h) *First Aid Room:* This room should be large enough to contain a stock of first aid supplies, a stretcher and also a cot or bed.

(i) *Meeting Rooms:* If possible, especially in larger shops, a meeting room large enough for safety meetings, etc., should be provided. Special acoustical treatment is desirable so that meetings can be conducted while the shop is in operation. The lunch room could be designed to serve this purpose.

3.5.3 Heavy Repairs

Where heavy repairs are performed in the same shop the following must be considered:

(a) *Blacksmith Shop:* A blacksmith shop is generally required. Usually both gas and electric welding equipment can be contained in the same shop.

(b) *Woodworking Shop:* A woodworking shop, located near the lumber store, with a dust collection system to dispose of sawdust and shavings.

(c) *Air Brake Room:* An air brake room, if provided, with special emphasis placed on dust and temperature control.

(d) *Pipe Fitters Room:* This is required usually in larger installations where pipe fitters are employed.

3.6 MECHANICAL CONSIDERATIONS

3.6.1 Lighting and Electrical

(a) General lighting in the shop should be not less than 50 ft-c maintained at floor level.

(b) Convenience outlets to be provided for small tools, etc. 110 v, 60 Hz, single phase.

(c) Compatible welding outlets as required.

3.6.2 Heating

(a) Many different types of heating systems can be adapted to an installation of this type. Below is a partial list that can be referred to the mechanical engineer to aid in selecting the system for each specific location.

1. Forced warm air
2. Steam—high and low pressure
3. Hot water
4. Individual fired gas unit heaters
5. Electric
6. Infrared

3.6.3 Ventilation

Most installations of this type do not require any special ventilation, but ample ventilation should be provided to meet local codes. Special exhausters may be required at critical areas such as welding stations, etc.

3.6.4 Gutters and Downspouts

Plumbing codes usually dictate the size of gutters and downspouts required for various roof areas. Where possible, all roof drainage should be connected to the area storm sewer system.

3.6.5 Sewers

(a) Roof drainage and area drainage should be disposed of through the storm drainage system.

(b) Drainage from shop floors and areas where industrial wastes may be encountered should be properly treated before being discharged to a storm or sanitary sewer. Sanitary sewers should be connected to a city sewer where available. Where city sewers are not available, the installation should conform to the local and state health codes.

3.6.6 Separation, Recovery or Disposal of Oil

Special study will be required for this subject and it is important to call upon the services of the environmental engineer.

3.7 FINISH

3.7.1 Interior

A wide variety of finishes can be applied to the interior. Lining materials, particularly in shop areas, should be highly impact- and abrasion-resistant and reflective, as well as easy to maintain at low cost. Insulation shall be provided as required.

3.7.2 Exterior

The exterior finish is left up to the discretion of the designer. It is highly desirable to use products that require little maintenance. Metal siding, brick, concrete blocks, and concrete are all commonly used.

3.8 MISCELLANEOUS CONSIDERATIONS

3.8.1 Walls

Except in exceptional circumstances, a totally enclosed building is desirable. Walls adjacent to tracks can frequently be equipped with a multiplicity of truck doors, which will facilitate the spotting or moving of material or portable equipment.

3.8.2 Windows and Skylights

Windows in shop areas are of questionable value. They cannot take the place of adequate artificial lighting, but may supplement it. Glass is easily broken so if windows are to be installed, they should be glazed with plastic. Plastic skylights should be considered. Clear windows should be placed so that the car mover operator can see through the building to observe car movement, etc.

3.8.3 Firewalls

Applicable building codes should be checked carefully.

3.8.4 Doors

(a) *Personnel Doors:* The use of truck or track doors for personnel movement is uneconomic and wasteful of time, heat and power. Sufficient doors should be provided at strategic locations to eliminate the use of larger doors. The doors should be installed using extra heavy hardware and door closers. Heavy steel doors are most economical in the long run.

(b) *Truck Doors:* Overhead-type doors are the most common and desirable. Size should be at least 12 ft high and 10 ft wide, with 14 ft high and 12 ft wide optimal.

(c) *Track Doors:* Minimum size is 14 ft wide and 22 ft high. Recommended type is steel rolling overhead door, with speed of 2 ft per second. Automatic stops and interlocks are necessary for protection of equipment and door mechanisms. All governing clearance laws should be checked before the doors are selected.

3.9 MECHANICAL

3.9.1 Jacking Systems and Related Equipment

(a) *Portable Jacks:* These jacks are either electric or air-operated and jacking pads are required. Pads should extend the full length of the shop so that jacking can be done at any location. Pads are constructed of reinforced concrete of various depths depending upon soil conditions.

(b) *Electric Jacks:* These are furnished in pairs of two 40- to 50-ton outside jacks with no center jack. The jacking speed is 4½ ft per minute unloaded and 2¼ ft per minute loaded. Jacks traverse under different widths of cars and under the side frame for repacking, etc. Each pair of jacks is a self-contained unit.

(c) *Hydraulic Jacks:* These jacks are built-in and are installed in sets composed of two 75-ton outside jacks and a 150-ton center jack with raising speeds approximately 8 ft per minute. The outside jacks are used for standard jacking, repacking, spring removal, etc. The center jack is used for center sill jacking of the cars and jacking under the bolster for repacking, spring removal or other miscellaneous jobs. A single pumping unit will usually handle several tracks.

(d) *Tie Downs:* Tie downs are required for straightening and pulling draft gears and should be installed whether portable or built-in jacking equipment is used.

3.9.2 Jib Cranes

Two jib cranes are required per track where built-in jacking equipment is used, normally about 16 ft center to center of support posts and offset 12 in to 18 in to allow spring plank removal. A support post is required, and latches in the "open" and "closed" positions. In the closed position they should be designed to have a capacity of from 3 to 5 tons and are not designed for loading in the open position. Single column jib cranes can also be used.

3.9.3 Hoists

Three hoists are required for each jib crane and are used for truck disassembly. The two outside hoists lift side frames and the center hoist raises the truck bolster. These are usually one-ton electric or air with hoisting speeds of 8 ft per minute.

3.9.4 Hose Reels

Hose reel mounting plates are welded to the jib post or the support post or both. The number of reels varies with needs of the railroad. Each location has one or more of the following reels: air, journal oil, solvent, oxygen–acetylene, electric welder and roller bearing grease. The supply piping can be either overhead or under the floor as required. If under the floor, protection must be provided around the base of the jib for these pipes.

3.9.5 Bins

Storage bins should be provided and located as conveniently as possible to supply equipment to all tracks. Double bins may be put between two tracks, supplying both. Care must be taken in locating bins to prevent interference with the efficient movement of wheels and other heavy equipment into the repair area. If possible, bins should be on the same side of the track as the control panels for the pullers and jacks and the boom of the jib cranes.

3.9.6 Car Moving Equipment

(a) *Automatic Car Moving Equipment:* This is a closed cable system with a car moving device mounted between the rails to contact the axle of the car. An axle contact arm is in the up position when traveling forward to move the cars, and either ratchets under the cars or lowers in its reverse direction. Movement is remote controlled from a push-button panel at the repair position. Maximum travel positions of the pulling device are controlled by either rotating cam limit switches or track limit switches, and various interlocking features are incorporated; for example, car pullers will not operate when doors are closed, jacks are up, or jib cranes are across the track.

(1) Two-Puller System: This is the most efficient system and is recommended for high-production light-repair facilities in classification yards. The inbound puller brings cars into the repair facility and the outbound puller handles cars through the shop and to the outbound storage area.

(2) Single Puller: Recommended for low-production shops or areas where sufficient trackage is not available for the two puller system. A single puller is used to bring the cars into the facility, position them in the repair spot, and then move them out.

(b) *Manual Type Pullers:* This is basically the same electric winch type equipment as used with the automatic pulling device above, except cables are exposed above the floor and a hook is attached to the car for movement.

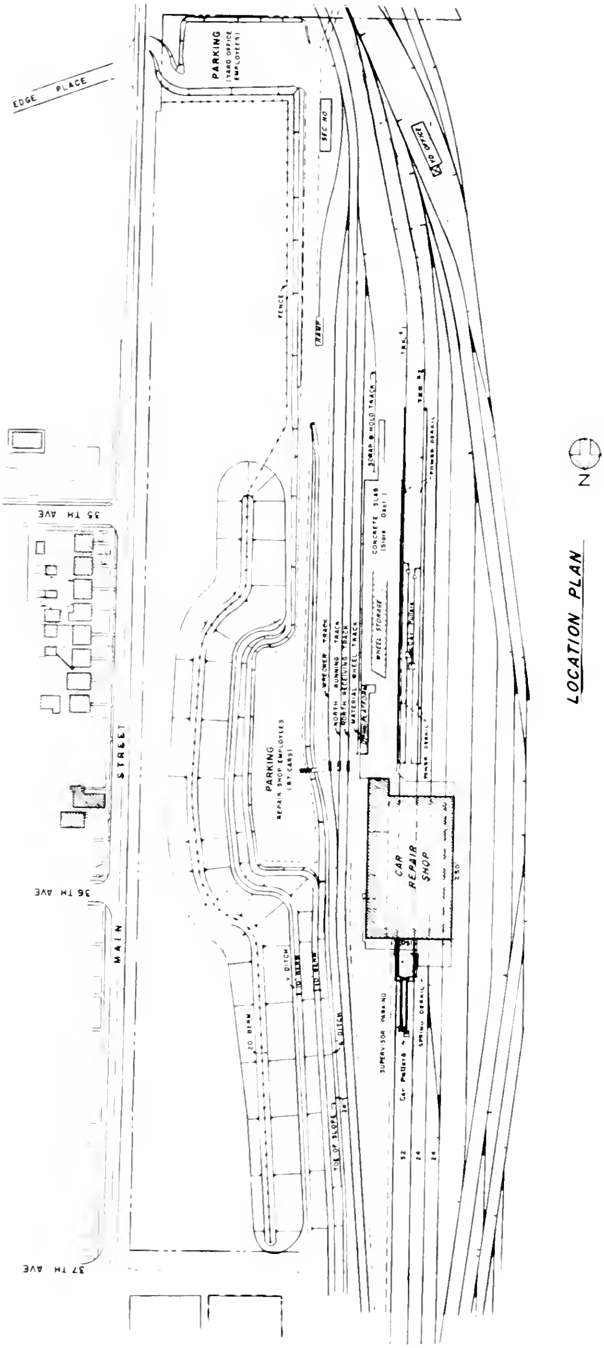
(c) *Mobile Equipment:* On- or off-track car movers, off-track tractors and cranes are utilized for moving cars. This equipment couples to the cars and moves them in and out of the facility and normally requires one or two men for operation. The on-track movers have the advantage of being able to negotiate switches.

3.10 ENVIRONMENTAL CONTROL

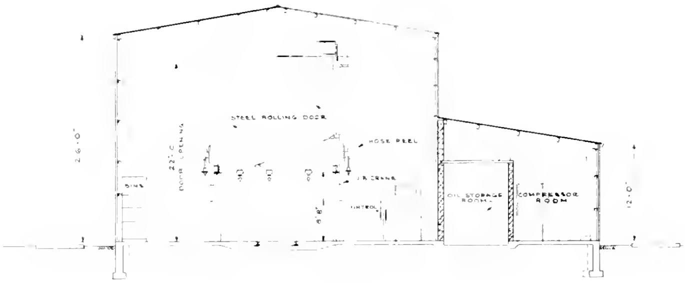
There are many wastes around such a facility that must be disposed of, such as car refuse, lubricator pads, wood and paper grain doors and oil. Applicable codes, appropriate local governing bodies and the company's environmental control engineer must be consulted for methods of handling. Incineration, once common, is now suspect. In some locations, it may be necessary to have scavengers pick up the material.

3.11 SUMMARY

Spot repair systems are the most efficient way to handle light repairs to freight cars. The more trackage available, the lower the switching cost. Two to three-and-one-half man hours are generally required per car for repairs. Automatic car moving equipment requires less manpower to operate than any other type of equipment. Built-in jacking equipment can normally be justified if the shop works at least 16 hours a day. Track centers should be not less than 26 ft, with 30 ft to 40 ft preferable. Buildings should be totally enclosed with doors, and heated in most locations.



LOCATION PLAN



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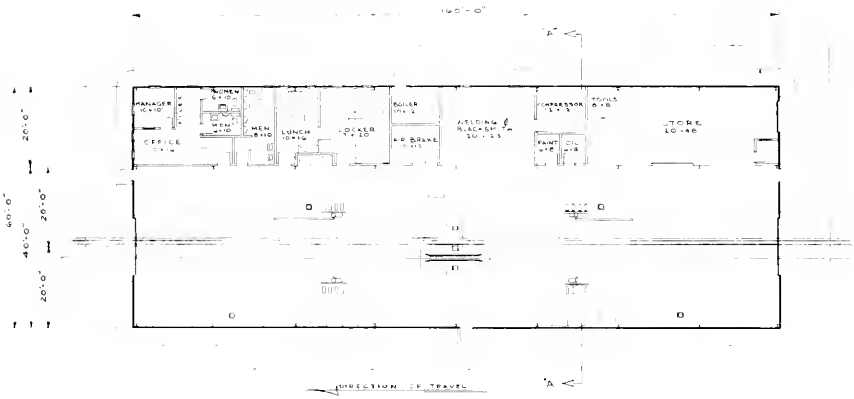
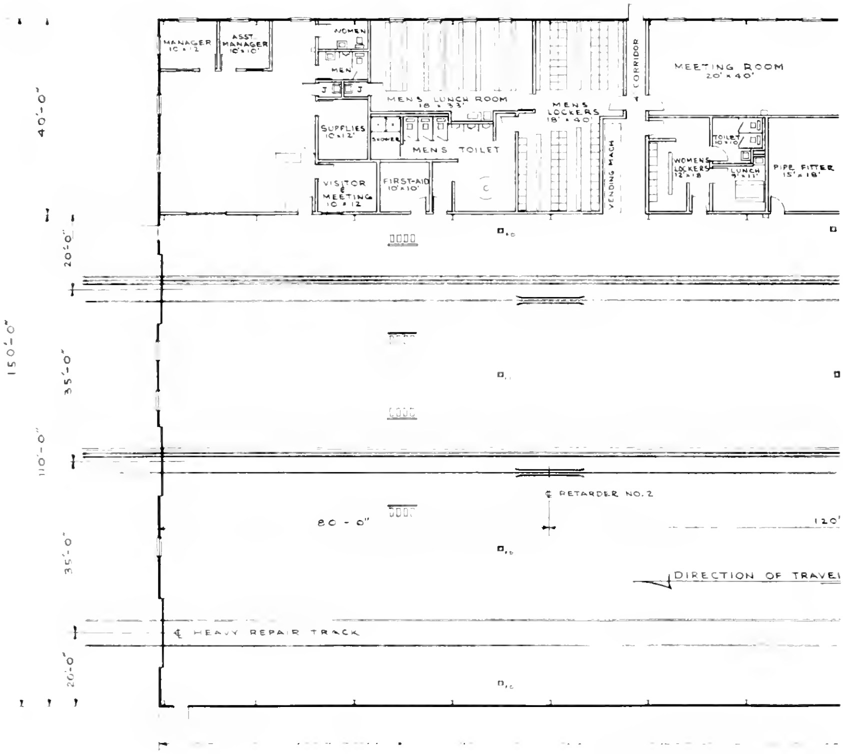
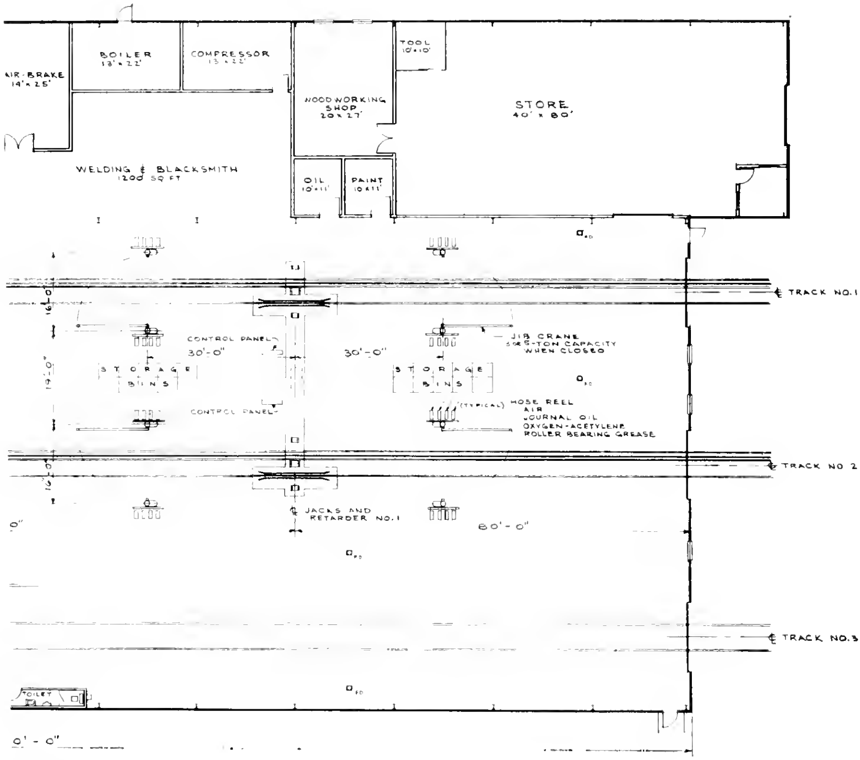


ONE SPOT CAR REPAIR BUILDING


MANAGER 10' x 12'
ASST. MANAGER 10' x 10'
WOMEN
MEN
SUPPLIES 10' x 12'
VISITOR & MEETING 10' x 12'
FIRST-AID 10' x 10'
SHOWER
MENS TOILET
MENS LUNCH ROOM 18' x 33'
MENS LOCKERS 18' x 40'
VENDING MACH
CORRIDOR
MEETING ROOM 20' x 40'
TOILET 10' x 10'
WOMENS LOCKERS 12' x 18'
LUNCH
PIPE FITTER 15' x 18'
40'-0"
20'-0"
150'-0"
35'-0"
110'-0"
35'-0"
20'-0"
℄ RETARDER NO. 2
80'-0"
120'
DIRECTION OF TRAVEL
℄ HEAVY REPAIR TRACK

TWO SPOT CAR



REPAIR BUILDING

Manual Recommendations

Committee 13—Environmental Engineering

Report on Assignment 1

Water Pollution Control

J. L. Goss *(chairman, subcommittee)*, C. A. Obma *(vice chairman, subcommittee)*, D. J. Inman, F. L. Manganaro, J. C. Neal, G. H. Nick, N. E. Smith, R. J. Thompson.

Your committee has broken down its work on the design of facilities for treatment of railway waste waters into three categories. Data on the first and second categories are now included in the Manual on pages 13–1–7 through 13–1–21. The following report on the third category is now being submitted for adoption and publication in the Manual.

1.2.5.3 Waste Water with Pollutants Other Than Oils, Greases or Sanitary Wastes, and Having a BOD; Such as From Box Car Cleaning and Washing. Controlled by Removal of Settleable Solids, pH Adjustment, and Removal of Suspended Solids

(a) Definition of terms.

BOD (Biochemical Oxygen Demand)—A test which measures the quantity of oxygen utilized in the biochemical oxidation of organic matter in water in a specified time and at a specified temperature. It is an index to the degree of organic pollution in the water.

DO (Dissolved Oxygen)—Oxygen that is freely available in water. In a stream or lake, oxygen is derived directly from the air and from oxygen given off by the photosynthesis of aquatic plants.

COD (Chemical Oxygen Demand)—A test which measures the oxygen equivalent of that portion of the organic matter that is susceptible to oxidation by a strong chemical oxidant.

pH—A term which represents the hydrogen ion concentration in a solution which reflects the balance between acids and alkalies. A pH of 7 indicates neutrality; pH values lower than 7 indicate acidity and values higher than 7 indicates alkalinity.

Turbidity—An expression of optical properties of water where light is scattered or absorbed rather than transmitted in a straight line. Turbidity is caused by a suspension of finely divided materials such as clay, silt or organic matter.

Chlorides—Chlorides are universally present in sewage and many industrial wastes. Chlorides are not removed by any conventional sewage or waste treatment process.

Phosphorus—Phosphorus, in the ortho form, is a nutrient that will stimulate algae blooms in surface waters under certain conditions. These conditions are relatively warm temperature (+65 F), appreciable penetration of sunlight into the waterbody, and the presence of a substrate of carbon dioxide.

Settleable Solids—Settleable solids are solids in an aqueous solution that do not remain in suspension but either settle to the bottom or float to the top during a defined period of quiescent settling.

Suspended Solids—Suspended solids are solids that remain in suspension during the quiescent period in determining settleable solids.

Enzymes—Enzymes are any of the various complex organic substances originating from living cells and capable of producing, by catalytic action, certain chemical changes in organic substances.

(b) Preliminary Considerations

In order to design an efficient waste treatment system for a car cleaning and washing facility, a survey should be conducted and the following information obtained:

1. Number and type of cars to be washed.
2. Type of progression system that will be the most efficient.
3. Track requirements to support the wash rack.
4. Whether sweeping or vacuuming will be conducted prior to washing cars.
5. Type of material that will be washed out of cars.
6. Whether the washing facility will be used during freezing weather and whether heat and hot water will have to be provided.
7. Whether main line water pressure can be utilized in the washing or whether additional pressure will be required.
8. Whether all storm runoff, except that actually falling on the washing platform, can be directed into a storm sewer system rather than through the treating facilities.
9. A flow measurement of the effluent from the wash rack.
10. Analysis of the effluent to include determination of settleable solids, suspended solids, pH, phosphates, chlorides, BOD, and others if deemed necessary.
11. The level of effluent purity that must be maintained to comply with pollution regulations.

(c) Plant Facilities

Specific design details of a car washing and water treatment plant are omitted since the requirements vary and design details are readily available from consultants. Careful consideration should be given to the type of facility, the location and topography of the plant site, operating costs, and the probable type of supervision and maintenance required. Attention should be given to design for adequate access to valves, pumps, and other mechanical and electrical equipment. Particular attention should be given to protection of plant units and piping to permit dependable operation during freezing weather. With a progression system, the washing platform should be constructed with sufficient length to spot at least two cars at a time. Drains to a primary settling basin should be provided for the platform. Drainage should gravitate to the settling basin if possible and drains should not be sized less than 8 inches in order to facilitate cleaning. Drainage inlets should be fitted with grates to prevent large foreign objects from entering the drains. A trough in the bottom of the platform is desirable and would serve as an initial settling basin. The trough should be wide enough to facilitate cleaning with shovels and should be covered with a grating. Diversion of the uncontaminated portion of the storm water runoff will greatly reduce treatment plant size. Sludge, sediment, trash and other wastes from the cleaning and treatment operation should be disposed of by incineration or dumping. Either method demands good housekeeping in order to avoid additional pollution problems. It is imperative that all new car cleaning facilities be built as integrated systems with adequate disposal facilities included in the operating plant.

(d) Control by Removal of Settleable Solids

A primary settling basin should be designed to provide a minimum of 30 minutes detention time to permit solids to settle. The effluent from this basin is then diverted into either a large lagoon system, city sewer, or, if necessary, to a treating plant for further treatment. A method of removing solids from the settling basin should be provided. The nature of the removed solids will, necessarily, vary widely. In general, the settleable solids will contain appreciable amounts of granular and gritty material that cannot be pump-removed as a sludge. The indicated removal mechanism would be a drag-out type with a ramp slope of not greater than 30°. A considerable fraction of the separable solids will be floatable, including some oils and greases. A separately driven ramp skimmer should be provided for their removal, to avoid odorous and unsightly scum accumulations. Removed solids are discharged to "tote boxes" for scavenger removal. In freezing latitudes, housing over of the settling basin and solids discharge area is advisable. Completely automatic operation can be achieved by interlocking the motor starters with car washer mechanism or the water supply pumps of the car washer.

(e) pH Control

If the effluent from the wash rack or primary settling basin carries an unacceptable pH, adjustments should be made by either adding acid or an alkali.

(f) Operation of Facilities

A complete description of the plant facilities, effluent criteria, competent supervision, and a well trained operator are the prerequisites of an efficient and economical plant operation.

(g) Disposal of Effluent

Outlets for waste waters can be classified into three categories:

1. City sewerage system.
2. Oxidation ponds.
3. Streams, rivers or lakes.

A city sewerage system would be the preferred choice inasmuch as simple pretreatment is usually adequate. Generally more elaborate and sophisticated works are required for treating wastes discharged into surface waterways. Oxidation ponds (lagoon system) are a good choice. Ponds in porous soils are not recommended due to ground water infiltration.

A lagoon system is an economical way to treat effluent from the primary settling basin of a car washing facility if the real estate is available. The number of lagoons or detention time will depend on the analysis of the effluent. As to design standards, some authorities on oxidation ponds recommend design loading varying from 20 lb to 100 lb BOD per acre per day. Effluent quality is proportional to organic loading. The average depth of oxidation ponds is about 4 ft. Shallow ponds stimulate weed growth which is undesirable. Deep ponds do not permit sufficient circulation to maintain aerobic conditions. The use of enzymes have been used to reduce the BOD and COD.

Aerated lagoons should be considered where low BOD effluent is required, or where available lagoon space is limited. Aerated lagoons achieve comparable BOD removal with half or less lagoon volume than that of an oxidation pond. Depths of up to 10 to 12 ft are normally used which permits additional space savings. Aeration is accomplished with floating electrically driven surface entrainment aerators, or with compressed air diffused through a submerged grid. The latter system would be used in cold weather climates as freezing seriously hampers the floating aerators. Most state pollution control authorities prescribe design criteria for both oxidation ponds and aerated lagoons.

Effluent out of lagoons can be discharged into water courses if it meets stream criteria. Chlorination of the effluent may be necessary, depending on state regulations.

REFERENCES

(1) Billingsley, W. E., et al., "Methods and Materials to be Used in Car-Cleaning Facilities", AREA Bulletin, Vol. 68, No. 602, November 1966.

(2) Minnesota Pollution Control Agency—Division of Water Quality—Section of Standards and Surveys, Vol. 5, 1964–1965.

Report on Assignment 4

Industrial Hygiene

R. S. Bryan, Jr., *(chairman, subcommittee)*, R. A. Bardwell, J. J. Dwyer, W. D. Peters, T. A. Tennyson.

Your committee submits the following revision of Section 4.3 TOILET FACILITIES of Part 4, Industrial Hygiene of Chapter 13, Environmental Engineering with the recommendation that it be adopted and published in the Manual to replace present Section 4.3 on pages 13–4–6 and 13–4–7

4.3 TOILET FACILITIES

4.3.1 Toilets in Fixed Locations

4.3.1.1. Flush-Type Toilets

(a) Flush-type toilets should be used whenever feasible. Installation should be in accordance with state and local codes. In the absence of such codes, the latest revision of American Standard Plumbing Code, NSA A40.7 should be followed.

4.3.1.2 Pit Privies

(a) Pit privies may be used where other toilets are impractical. Their installation should be approved by the public health authorities having jurisdiction. In the absence of specific local regulations, construction and maintenance should be in accordance with Specifications for the Sanitary Privy Z4.3 (Supplement 108 to Public Health reports) or latest revision, published by the American National Standards Institute.

4.3.1.3 Chemical Toilets

(a) Chemical toilets which use caustic soda or other chemicals for disinfecting the toilet wastes may be used at special locations.

4.3.2 Toilets on Locomotives, Cabooses, Camp Cars, Etc.

Regulations covering railway sanitary equipment are contained in Title 42—Public Health, Part 72.154 railroad conveyances; discharge of wastes.

4.3.2.1 Flush-Type Toilet

(a) Sanitary water tank and pipelines must be protected against freezing. This type of toilet will become obsolete under new regulations.

4.3.2.2 Electric Incinerator Toilet

(a) The advantages of this type of toilet are that it is a waterless system, can be installed without expensive piping, cannot freeze and reduces waste to odorless inorganic ash eliminating the disposal of raw waste.

(b) The disadvantages are objectionable combustion odors, excessive length of disposal cycle and high maintenance costs.

4.3.2.3 Combustion-Type Toilets

(a) The fuel used can be fuel oil, propane gas or natural gas. The waste is reduced to a bacteria-free inorganic ash during the combustion cycle. All wastes are deposited through the hopper into the disposal section. When the seat is closed, the disposal section becomes the combustion chamber. A heat shield closes and contains the heat. Operation is fully automatic. When the seat cover is lifted, the hopper flap opens, the exhaust blower turns on, and the timer switch is set by the gear mechanism attached to the seat-cover hinge. When the seat cover is closed after use, the timer switch is released, the hopper flap closes, the burner is spark ignited and the combustion cycle starts. The timer switch controls the length of the combustion cycle, transfers to the cooling cycle and finally cuts off.

(b) The disadvantages are the same as those of the electric incinerator toilet. The disadvantages can be overcome by modifications such as increasing the temperature and adding an external defroster type blower.

4.3.2.4 Recirculating Flush-Type Chemical Toilet

This type of toilet has been used in airplanes, boats, railroad cars, and locomotives.

(b) The toilet tank is filled to the proper level with water and a deodorizing chemical such as the quaternary ammonium compounds. One formulation contains 40% alkyl dimethyl-benzyl ammonium chloride as the active ingredient and 60% urea with dye and perfume added as the inert ingredient. The flush switch when pressed trips a timer which delivers power for 9 to 11 sec. The pump motor rotates the screw impeller within the water pump to draw tank fluid in through the concurrently rotating, self-cleaning disc-type filter of the pump assembly. The filter prevents entry of large particles into the pump. From the water pump, the fluid is delivered by hose to the hopper ring of the stainless steel bowl for spiral flushing action. A hinged spout at the base of the bowl prevents splash and view of the tank contents. In the event of power or mechanical failure, this spout can be pushed free of its spring latch, thus permitting the toilet to be used as a static unit.

(c) The tank can be filled from either outside the train or inside the train. The chemical is added to the 3-gal prime charge in the tank. Inspection includes cycling the toilet several times at each servicing to check for adequate flush pattern, time of cycle and external leakage. No lubrication or adjustments are required.

(d) The frequency of draining and cleaning the tank is a function of usage. Based on two-thirds pint per use with an 11-gal-capacity tank, the toilet would accommodate 60 uses. The deodorizing chemical will hold the contents of the tank odor free for the duration of the tank usage, or not to exceed 124 hours (slightly over five days) at room temperature.

(e) The disadvantages of the recirculating flush-type units are higher initial cost, necessity for draining and cleaning, transmission of disease, odor, accidental spillage, freezing, and subsequent sanitary disposal of the contents of the tank.

(f) Chemical charges may be applied from either pre-mixed containers or mixed directly within the toilet. The 3-gal prime charge may be varied as follows according to operating environment:

Constituent	*Warm Climate*	*Cold Climate*
Water	3 gal	1½ gal
Chemical	1 dosage	2 dosages
Diethylene glycol	None	1½ gal

(g) Toilets are emptied into either a sanitary sewer, septic tank, or service cart, depending on facilities at the service area. All sanitary sewer connections and septic tank installations should conform to local plumbing codes.

(h) Requests for approval of servicing areas should be addressed to the Commissioner, Food and Drug Administration, 5600 Fishers Lane, Rockville, Maryland 20852.

4.3.2.5 Biodegradable Toilet

(a) Operation is based on a biodegradable treatment principle through which microoganisms contained in a tank of redwood bark reduce waste to CO_2 and a liquid effluent.

(b) Effective July 1, 1972, FDA approval has been given to the discharge of "suitably treated" toilet waste waters onto railroad rights-of-way. If further treatment is required, the effluent can be passed through a chlorinator before discharge.

(c) The unit requires no maintenance other than ordinary cleaning with a liquid detergent and addition of tablets to the chlorinator as required.

(d) Units should be protected against freezing and against strong chemicals introduced into the processing tank.

4.3.2.6 Filter/Sterilization Type Toilet

(a) This type of toilet separate the solids from the liquid. It macerates the solids and discharges the liquids in a sterile condition by means of chlorination with each flush.

(b) The filter/sterilization tank allows more than 98% of the waste to pass in micron-size particles into the final stage of the tank where it is sterilized. The toilet tissue fibers are retained in the filter tank.

(c) The filter is semi-permanent filter. Back flushing the tank with hot or cold city water for approximately 20 minutes will clean and renew the filter for reuse. This eliminates the need to replace the filter cartridge for several uses.

(d) This type of toilet must be protected from freezing if used in extremely low temperature areas.

Manual Recommendations

Committee 15—Steel Structures

Report on Assignment B

Revision of Manual

D. V. Messman (*chairman, subcommittee*), E. S. Birkenwald, E. Bond, T. J. Boyle, H. L. Chamberlain, A. C. Danks, J. L. Durkee, G. F. Fox, T. J. Mearsheimer, G. E. Morris, D. L. Nord, R. D. Nordstrom, D. D. Rosen, G. W. Salmon, J. E. Stallmeyer, C. R. Wahlen.

Your committee submits for adoption and publication the following revisions to Chapter 15 of the Manual:

PART 3—FABRICATION

Delete Art. 3.1.7 Straightness and Dimensional Tolerances, on pages 15–3–3 and 15–3–4, substituting therefor the following revised Art. 3.1.7:

3.1.7 Dimensional Tolerances for Structural Members

3.1.7.1 General provisions

(a) Members and parts of members shall be straight, true to line, and free from twists and bends. In determining acceptability under this general requirement, the tolerances stated hereinafter shall be applied as indicated. When more accurate conformance to detailed dimensions is required for any member or part of a member, it shall be specifically stated on the contract plans.

(b) Surfaces intended to be in a common plane at connections, joints, splices and bearings shall have no offset greater than ⅛ inch unless properly accommodated by fillers.

(c) For rolled shapes or plates, the tolerance for any dimension shall conform with the requirements of ASTM Specification A 6 except as otherwise shown on the contract drawings.

(d) The tolerances stated hereinafter have been established to apply primarily to members fabricated by welding. Riveted and bolted members shall be well within these specified tolerances, as shall rolled members to the extent not excepted by paragraph (c) above.

(e) Allowable deviations:

1. Deviation from detailed length:

For members with ends milled for bearing and members with end connection angles faced ...... ± $\frac{1}{32}$ inch

For framed members not milled or faced:

Lengths of 30 ft and under .... ± $\frac{1}{16}$ inch

Lengths over 30 ft .... ± ⅛ inch

For other members .... ± ¼ inch

2. Deviation from detailed straightness or curvature, that is, sweep or deviation from camber:

$$\pm \tfrac{1}{16} \text{ inch} \times \frac{\text{No. of feet of length between points}}{10}$$

or

± ¼ inch, whichever is greater.

3. Deviation from parallelism between corresponding elements of the same part at different cross-sections along the length of the member (i.e. twist):

   For box sections .... $\frac{1}{16}$ inch in 12 inches bevel

   $$\times \frac{\text{No. of feet of length between sections}}{10}$$

   For I sections .... $\frac{1}{8}$ inch in 12 inches bevel

   $$\times \frac{\text{No. of feet of length between sections}}{10}$$

4. Deviation from detailed depth or width, measured at the centerline of each web or flange:

   $\pm\left(\frac{1}{8} \text{ inch} + \frac{D}{500}\right)$, where D is the dimension in inches being considered:

5. Out of square for box-shaped members:

   The deviation of parts on opposite sides of a member measured transverse to the principal axis of the cross-section shall not exceed

   $\frac{3}{16} \text{ inch} + \frac{D}{1000}$

   where D is the nominal distance in inches between the opposite sides.

6. Lateral deviation between the center line of flanges measured transverse to the theoretical centerline of web of I-shaped members at splice points and contact points of connection shall not exceed $\frac{3}{16} \text{ inch} + \frac{D}{1000}$ where D is the nominal distance in inches between the flanges.

7. Combined warpage and tilt of flange at any cross-section of welded I-shaped beams or girders shall be determined by measuring the offset at toe of flange from a line normal to the plane of the web through the intersection of the centerline of web with the outside surface of the flange plate. This offset shall not exceed 1/100 of total width of flange or $\frac{1}{4}$ inch, whichever is greater, at any point along the member and $\frac{1}{32}$ inch at any bearing.

8. Out of flatness of seats or bases:

   To be set on grout: $\frac{1}{8}$ inch max.

   To be set on steel, hard masonry, canvas or lead:
   1/100 inch max.

9. Deviation from flatness or detailed curvature of panels of plate elements shall be determined by measuring offsets perpendicular to a templet edge having the detailed straightness or curvature and a length not less than the smaller of $d1$ or $d2$ as defined below and not more than 1.5 times the smaller of $d1$ or $d2$. The measurements shall be taken between points of contact of the templet edge with the plate. The templet edge may be placed anywhere within the panel of plate. The maximum offset shall not exceed the greater of two values computed as follows:

   (a) For girder webs without intermediate stiffeners $\frac{d}{200\sqrt{t}}$ but not greater than $\frac{3}{4} \times t$

   (b) For all stiffened plate elements $\frac{d}{100\sqrt{t}}$ but not greater than $1\frac{1}{2} \times t$

   where

   d is the least dimension in inches of:

*d*1 the maximum transverse distance between longitudinal flanges, edges or stiffeners,

*d*2 the maximum longitudinal distance between transverse edges or stiffeners, or

*d*3 the clear distance between points of contact of the templet with the plate or web.

t is the minimum thickness of the plate within the panel in inches.

10. Deviation from detailed position of secondary parts and connections. (The detailed position is the detailed distance from the member end connection, center line of bearing, or other primary working point or line):

   a. For each secondary part not used for connection of other members except bearing stiffeners. (That is, a part such as a plain stiffener plate or bar.)
   ± ¼ inch

   b. For each secondary part used for connection of secondary members, and also for bearing stiffeners. (That is, a part used for connections in which the holes would be permitted to be punched full size if the connections were bolted.)
   ± ⅛ inch

3.1.7.2 Special provisions for trusses (to be developed)

Delete Section 3.2 Riveted and Bolted Construction, on pages 15–3–6 to 15–3–9, incl., substituting therefor the following revised Section 3.2:

3.2 RIVETED AND BOLTED CONSTRUCTION

3.2.1 Rivets and Riveting

(a) Rivet dimensions shall conform to the current requirements of the American National Standards Institute for large rivets, ½ inch in nominal diameter and larger, ANSI Standard B18.4.

(b) Rivets shall be heated uniformly to a light cherry red and driven while hot to fill the holes completely. They shall be free from slag, scale and carbon deposit. Loose, burned, or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal and, if necessary, they shall be drilled out. Caulking or recupping shall not be done.

(c) Rivets shall be driven by direct-acting riveters where practicable. The pressure shall be continued after the upsetting has been completed.

(d) If rivets are driven with a pnuematic riveting hammer, a pneumatic bucker shall be used where practicable.

(e) Driven rivet heads shall be full, neatly made, concentric with the rivet holes, and in full contact with the member.

(f) Rivets of ASTM A 502, Grade 2, shall not be driven by hand.

3.2.2 High-Strength Bolts, Nuts and Washers

(a) High-strength bolts, nuts and washers shall conform to the current Specification for Structural Joints Using ASTM A 325 or A 490 Bolts of the Research Council on Riveted and Bolted Structural Joints. Other types of fasteners permitted by Art. 2 (d) of that Specification may be used provided special provisions governing their manufacture and installation are approved by the engineer.

3.2.3 Installation Procedure for High-Strength Bolts

(a) High-strength bolts shall be installed in accordance with the turn-of-nut method of current Specification for Structural Joints referred to in Art. 3.2.2 (a) All high-strength bolts shall have a hardened washer under the turned element. In addition, a hardened washer shall be used under the non-turned element of A 490 bolts used to connect A 36 material, and may be used under that element for other conditions if so specified by the engineer or elected by the contractor. Beveled hardened washers shall be used where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis.

3.2.4 Quantity of Field Fasteners

(a) The number of field rivets of each size and length furnished in excess of the nominal number required shall be 10 percent plus 10.

(b) The number of field high-strength bolts of each size and length furnished in excess of the nominal number required shall be 5 percent plus 5. The number of nuts and washers of each size and type furnished in excess of the nominal number required shall be 5 percent.

3.2.5 Size and Workmanship of Holes

(a) The diameter of holes punched full-size and of holes reamed or drilled shall be $\frac{1}{16}$ inch greater than the nominal diameter of the rivets or high strength bolts.

(b) The diameter of the punch shall be the diameter of the hole to be punched, and the diameter of the die shall be not more than $\frac{3}{32}$ inch greater.

(c) Holes shall be cylindrical, unless punched full-size, and perpendicular to the member. They shall be clean-cut without torn or ragged edges. Burrs on the outer surfaces shall be removed. Where the grip exceeds 4½ inches the holes shall be filleted $\frac{1}{32}$ inch.

3.2.6 Preparation of Holes for Shop Fasteners

(a) For meeting the requirements of this article, the following tabulation of acceptable substitutes, for use at fabricator's option, shall apply:

Requirement	*Acceptable Substitute*
Punching full-size	Drilling full-size or subpunching and reaming to size with or without all parts assembled
Subpunching	Subdrilling
Reaming with parts assembled	Drilling full-size with parts assembled
Subpunching ⅛ inch less in diameter than that of the finished hole.	Subpunching ¼ inch less in diameter than that of the finished hole.

(b) Holes to be reamed shall be subpunched or subdrilled.

(c) Except as prohibited by paragraph (f), holes may be punched full-size in A 36 material not more than ⅞ inch thick and in high-strength material not more than ¾ inch thick for fasteners which are not stressed by vertical live load. This provision applies to, but is not limited to, holes for stitch fasteners; lateral, longitudinal or sway bracing or their connecting material; lacing stay plates; diaphragms which do not transfer shear or other stress; inactive fillers; and stiffeners not at bearing points.

(d) Holes in rolled beams and plate girders, including stiffeners and active fillers at bearing points, in material not thicker than the nominal diameter of the fastener less ⅛ inch, shall be subpunched ⅛ inch less in diameter than that of the finished hole, and reamed to size with parts assembled.

(e) Holes in A 36 material thicker than ⅞ inch and in high-strength material thicker than ¾ inch shall be subdrilled ¼ inch less in diameter than that of the finished hole, and reamed to size with parts assembled.

(f) Where matching holes in two or more plies of material are required to be reamed with parts assembled and the assembly consists of more than five plies with more than three plies of main material, the matching holes in other plies shall also be reamed with parts assembled, with holes in these other plies subpunched ⅛ inch less in diameter than that of the finished hole.

(g) Other holes for shop fasteners shall be subpunched ¼ inch less in diameter than that of the finished hole, and reamed to size with parts assembled.

3.2.7 Preparation of Holes for Field Fasteners

(a) Field splices in plate girders and in truss chords shall be reamed or drilled full-size with the members assembled. Truss cord assemblies shall consist of at least three abutting sections, and milled ends of compression chords shall have full bearing.

(b) Holes for field fasteners where assembly is not required shall be either (1) subpunched or subdrilled ¼ inch less in diameter than that of the finished holes and reamed to size through steel templates with hardened steel bushings, or (2) drilled full-size through steel templates with hardened steel bushings.

(c) Holes in A 36 material thicker than ⅞ inch and in high-strength material thicker than ¾ inch shall be either (1) subdrilled ¼ inch less in diameter than that of the finished holes and reamed to size with parts assembled, or (2) drilled full-size with parts assembled.

(d) Holes for field fasteners in lateral, longitudinal or sway bracing shall conform to the requirements for shop-fastener holes in such members.

3.2.8 Templates for Reaming and Drilling

(a) Each steel template shall have hardened steel bushings accurately positioned with respect to connection center lines inscribed on the template.

3.2.9 Reaming and Drilling Through Templates

(a) Reaming or drilling full-size of field connections through templates shall be done only after the templates have been positioned with the utmost care, and firmly bolted. Templates used for the reaming of matching members, or of the opposite faces of one member, shall be exact duplicates. Templates for connections which duplicate shall be so accurately positioned that like members are duplicates and require no match-marking.

(b) When templates are used to ream or drill field connections of truss web members, at least one end of each such member shall be milled or scribed normal to the long axis of the member, and the templates shall be accurately set at both ends with respect to this milled or scribed end. Templates for reaming or drilling truss gussets shall be accurately positioned to the geometric dimensions shown on the shop plans.

(c) Templates for field-connector holes for joining floor sections to girders or trusses shall be positioned so as to space the field connectors correctly from the floor expansion joints.

3.2.10 Reaming and Drilling After Assembly

(a) Reaming, or drilling full-size, of assembled parts shall be done only after the parts are firmly clamped together with the surfaces in close contact. If necessary, parts shall be separated before riveting or bolting for removal of shavings.

3.2.11 Match-marking

(a) Parts assembled in the shop for reaming or drilling holes for field connectors shall be match-marked before disassembly. Diagrams showing match-marks shall be furnished to the engineer.

3.2.12 Alignment of Finished Holes

(a) The offset in any hole reamed ¼ inch in any ply of material measured from an outer ply after the hole has been finished for riveting or bolting, shall not exceed $\frac{1}{16}$ inch. Not more than 10 percent of the holes shall be offset as much as $\frac{1}{16}$ inch, and not more than 20 percent shall be offset as much as $\frac{1}{32}$ inch.

(b) The offset in any hole reamed ⅛ inch, or punched full-size, in any ply of material, measured from an outer ply after the hole has been finished for riveting or bolting, shall not exceed ⅛ inch. Not more than 10 percent of the holes shall be offset as much as ⅛ inch, and not more than 20 percent shall be offset as much as $\frac{1}{16}$ inch.

(c) If approved by the engineer, holes may be overreamed to meet these requirements, and larger rivets or bolts installed.

3.2.13 Fitting for Shop Riveting or Bolting

(a) The parts of riveted or bolted members shall be adequately pinned and firmly drawn together in close contact with bolts before riveting or final bolting is begun. Tack welding shall not be used. The drifting done during assembly shall be only such as to bring the parts into position and shall not enlarge the holes or distort the metal.

Your committee also submits for adoption the following editorial revisions to the Specifications for Steel Railway Bridges:

Revise Art. 1.7.8(c) on page 15–1–28 and Art. 2.7.3(c) on page 15–2–3 both to read as follows:

(c) Intermediate stiffeners on one side of a plate girder web may be used, provided they have the same moment of inertia, taken about an axis coincident with the center of web, as the minimum acceptable pairs of angles or plates. They shall be connected to the outstanding portion of the compression flange.

Revise Art. 1.5.7(c) on page 15–1–20 by inserting the word "preferably" after the word "lie."

Manual Recommendations

Committee 8—Concrete Structures and Foundations

Report on Assignment B

Revision of Manual

F. A. Kempe *(chairman, subcommittee)*, R. J. Brueske, G. W. Cooke, T. L. Fuller, L. M. Morris, J. M. Williams, J. R. Williams.

Your committee submits for adoption the following revisions to Chapter 8 of the Manual:

Pages 8-1-1 to 8-1-32, incl.

SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE RAILROAD BRIDGES AND OTHER STRUCTURES

On page 8-1-8, revise Art. 10a (1) to read as follows:

(1) For concrete subject to severe abrasion, such as concrete in water, pre-cast concrete piles, paving for sidewalks, platforms or roadways, floor wearing surfaces, and concrete cross or bridge ties, the loss in weight shall not exceed 40 percent.

Pages 8-3-1 to 8-3-16, incl.

SPECIFICATIONS FOR DESIGN OF SPREAD FOOTING FOUNDATIONS

On page 8-3-12, revise Fig. 6 by reversing the titles of the two sloping lines on the graph, making the straight line the "Clay" line and the curved line the "Granular material" line. (Revised Fig. 6 presented on next page).

Pages 8-20-1 to 8-20-15, incl.

SPECIFICATIONS FOR DESIGN OF FLEXIBLE SHEET PILE BULKHEADS

On page 8-20-4, delete in Art. 2 (c) the formula reading as follows:

$$p_1 = 1.27q\frac{xz}{R}.$$

Also, add at the end of Art. 2 the following paragraph:

"If the designer desires a more accurate solution for the loading obtained in (b), (c) or (d) phase, a trial wedge analysis should be carried out."

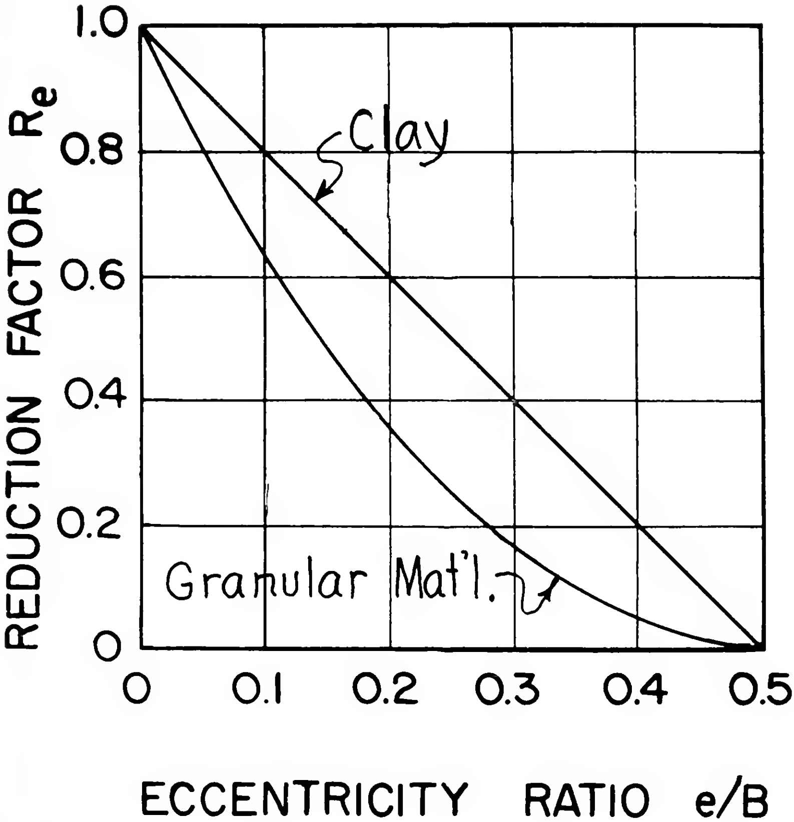


FIG. 6 CORRECTION FOR ECCENTRICITY OF LOAD (AFTER G.G. MEYERHOF)

Report on Assignment 1

Design of Masonry Structures

R. E. Pearson *(chairman, subcommittee)*, W. E. Brakensiek, M. J. Crespo, R. A. Dorsch, J. A. Erskine, W. L. Gamble, C. W. Harman, G. F. Leyh, J. H. Sawyer, Jr., A. Tedesko, J. W. Weber, G. A. Wolf.

Your committee submits for adoption the following revisions to Part 11 of Chapter 8:

Pages 8–11–1 to 8–11–7, incl.

SPECIFICATIONS FOR LINING RAILWAY TUNNELS WITH CONCRETE

A. SCOPE

(No change)

B. DESIGN

1. Interior Dimensions

Revise second paragraph to read, "On curved track, the lateral clearance shall be increased in conformance with AREA Manual Chapter 28, Part 1. The superelevation of the outer rail shall be in accordance with the recommended practice of the AREA."

2. Preliminary Data

(No change).

3. Floors

Floors should, if practical, be paved and may have either ballasted floor track section, Fig. 1E, or solid floor track section with ties embedded in concrete, Fig. 1D. In the latter case, rails shall be supported on creosoted tie blocks 8 in. by 10 in. by 2 ft 6 in., spaced about 19½ in. on centers, embedded in the concrete floor, with double-shouldered tie plates fastened to ties with suitable drive spikes or lag screws; superelevation shall be provided on curves by increasing the thickness of the tie blocks under the high rail.

4. Sidewalls and Arch

The depth of the sidewalls in hard, durable rock shall be at least 6 in. below the bottom of the gutter for ballasted track sections and at least 6 in. below the intersection of the floor surface with the sidewalls for solid track sections. In unsound rock, the sidewalls shall be carried down to stable foundation. At portals and vicinity, sidewalls shall extend at least 6 in. below the frost line.

The minimum thickness of the sidewalls and arch shall be:

a. Where temporary supports for excavation are not required:
   Single track—See Fig. 1A
   Double track—See Fig. 1C

b. Where temporary supports are required for face of excavation:
   Timber supports—See Fig. 1A
   Steel supports—See Fig. 1B or 1C

Timber sets are not recommended unless conditions are such that steel or bent rail sets are unobtainable.

Where timber sets are spaced less than 12 in. apart, the thickness of walls and arch shall be increased and side and arch loads computed to determine advisability of using reinforced concrete sections.

Steel sets are spaced at least 4 in. apart, and in general not greater than 4 ft apart. Where supports are used primarily to protect workmen from falling rock and do not carry much load, wider spacing may be used.

Lagging may be wood, steel lags, steel liner plates or steel water-diverting lagging. Where the nature of the rock and water conditions permit, lagging shall be spaced to allow clearance of 4 in. or more between lags to permit free access of concrete to the face of the tunnel excavation. Prior to concreting, remove as many lags as is possible. Where it is necessary to solid-lag for protection during excavation and where it is impractical to open up the lagging just prior to concreting, the space between the lagging and face of excavation shall be packed with lean concrete, durable stone rammed into place, coarse gravel placed by hand, or pea gravel placed pneumatically.

5. Construction Joints

Each section of the lining shall be adequately keyed to adjacent sections. Non-corrosive water seals shall be used where necessary (Fig. 1E). Monoliths shall not be longer than 40 ft through the tunnel and not longer than 30 ft within 120 ft of the portals.

6. Drains

Wherever groundwater is encountered, vertical and diagonal openings, trench drains, tile or iron pipe drains shall be installed between the concrete lining and rock. Provide adequate outlets through sidewalls with the outer end of the outlets not less than 12 in. above the bottom of the gutter. Provide subdrains under the concrete floor wherever groundwater is found. Provide drains through curb to drain ballast section.

Wherever groundwater drains are installed, they shall be sealed to the rock so as to prevent being clogged when concrete is poured.

7. Refuge Niches

Provide refuge niches as shown on Fig. 1A through 1E at approximate intervals of 200 ft and staggered with opposite sides so that spacing of niches shall be approximately 100 ft. Bottom of niches shall be at elevation of bottom of track ties for ballasted track sections and at elevation of intersection of invert and walls for solid track sections. Where tunnels are more than 1 mile in length, larger refuge niches shall be provided at appropriate intervals to accommodate motorcars.

8. Conduit and Inserts

(No change).

C. FORMS

(No change)

D. CONCRETE

1. Specifications

(No change).

2. Proportioning

Concrete shall contain not more than 5.5 gal of water (including moisture in the aggregate) per sack of cement, and shall have a minimum compressive strength of 3750 psi in 28 days; the slump at the mixer shall not exceed 3 in. Concrete shall be air-entrained with air content in accordance with Part 1, Sec. J, Art. 4. Approved admixtures may be used if necessary to maintain workability with the required water-cement ratio.

3. Hand Placing

(No change).

4. Pneumatic Placing

(No change).

5. Pumping

(No change).

6. Shotcrete

(No change).

7. Order of Placing

(No change).

8. Compaction

(No change).

9. Laitance and Bonding

Concrete surfaces receiving new concrete shall be roughened and cleaned of all laitance, dirt and water before fresh concrete is placed. Just prior to placing fresh concrete, the old surface shall be flushed with a ½-in.-thick layer of grout or primed with an epoxy-polysulfide two-component bonding compound. Grout shall have the same proportions as the cement and sand in the regular mix. The consistency of the concrete and method of placement shall be such that laitance seams are not formed. If such seams are formed, they shall be completely removed before additional concrete is placed.

All loose or unsound rock shall be removed below walls and floors before concrete is placed. Where the type of rock makes this impractical, the floor and foundations for the walls shall be reinforced.

10. Drainage During Placing

(No change).

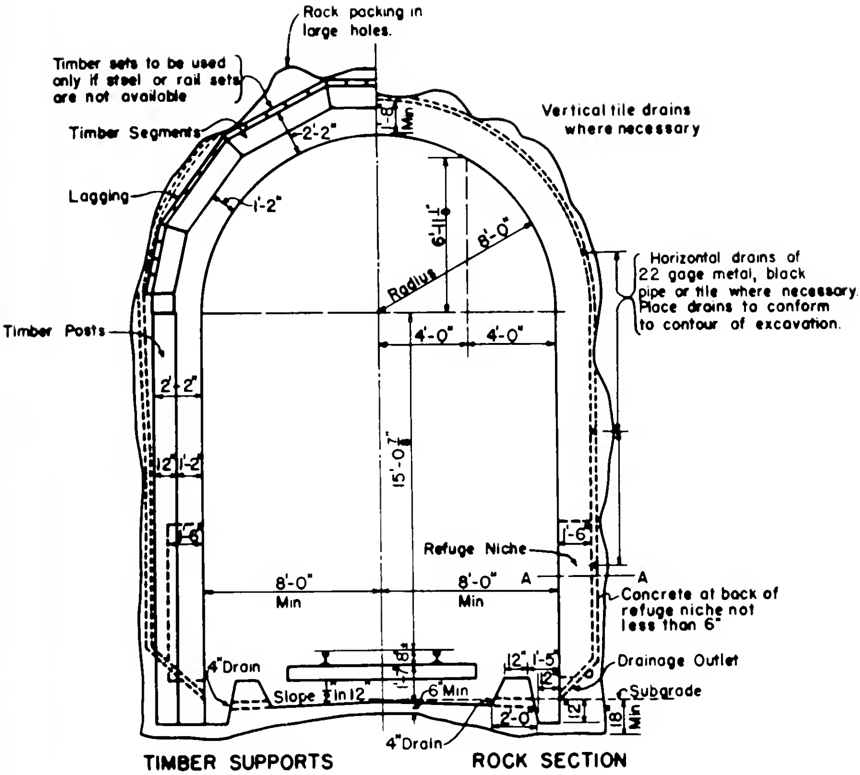
11. Curing and Cold Weather Protection

(No change).

E. CONSTRUCTION AND EXPANSION JOINTS

(No change)

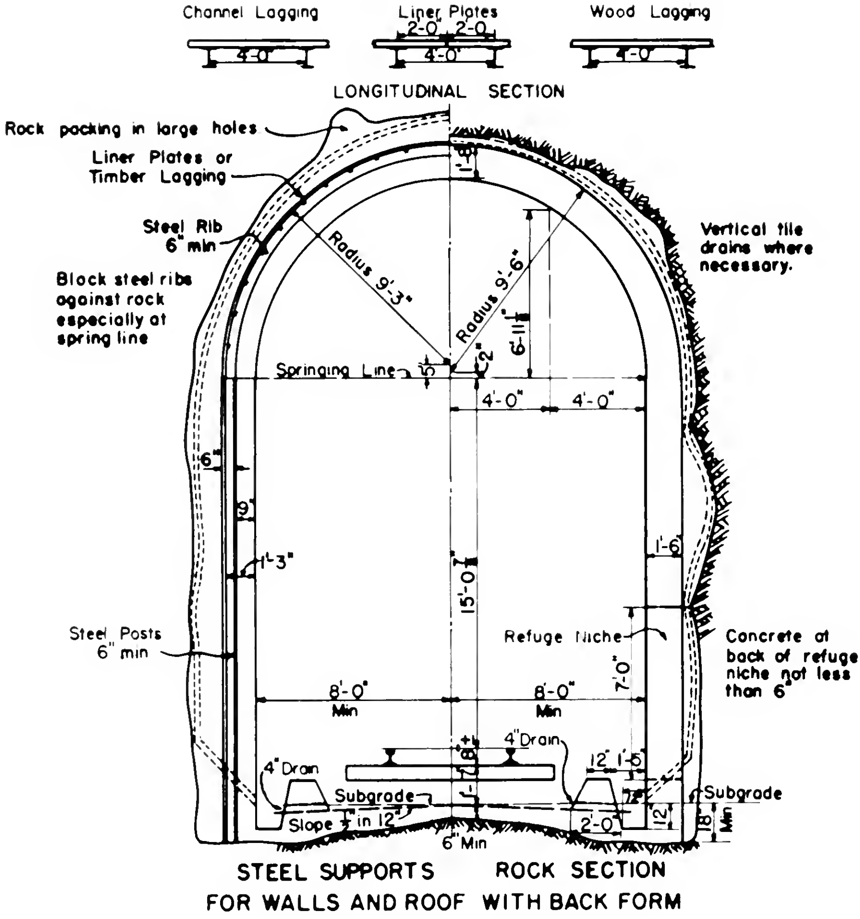
Delete Fig. 1, page 8–11–3, substituting therefor Figs. 1A, 1B, 1C, 1D and 1E, presented herewith.



SINGLE TRACK-TANGENT

PLAIN CONCRETE TUNNEL LINING

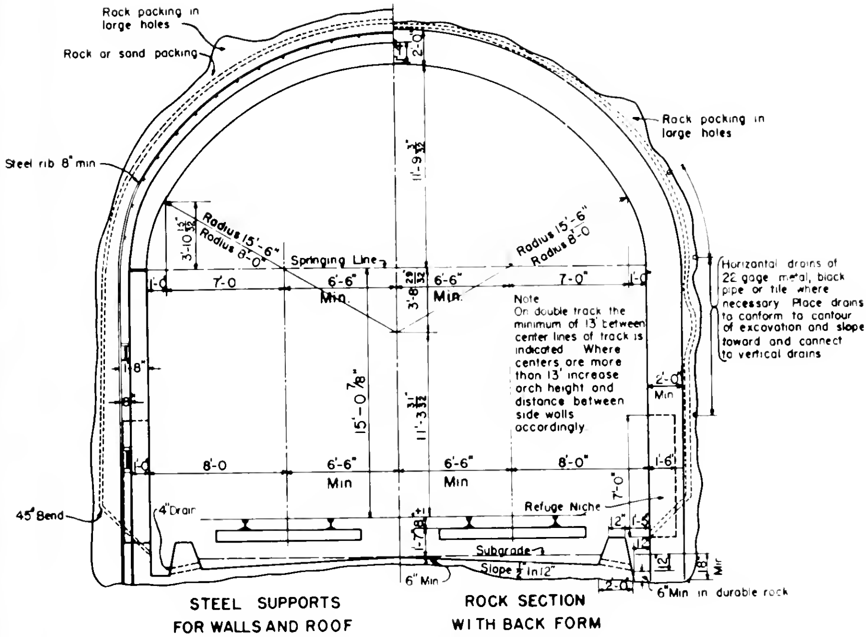
Fig. 1A – TIMBER OR NO SUPPORTS FOR WALLS & ROOF



SINGLE TRACK - TANGENT

PLAIN CONCRETE TUNNEL LINING

Fig. 1B



DOUBLE TRACK - TANGENT

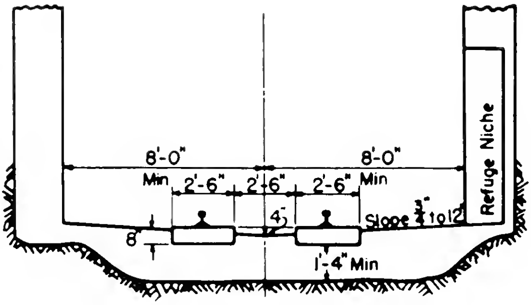
PLAIN CONCRETE TUNNEL LINING

Fig. 1C

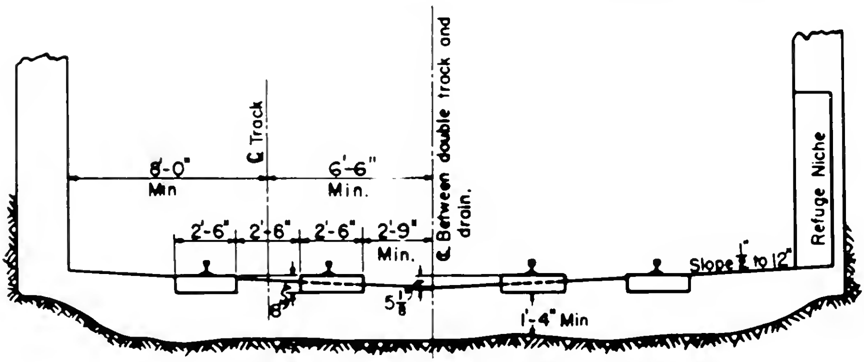
Super-elevation to be provided by increasing thickness of tie block under high rail on curves.

Necessary drains and catch basins to be provided at ends of tunnels.

Tie blocks to be creosoted and prebored for spikes and lagscrews.



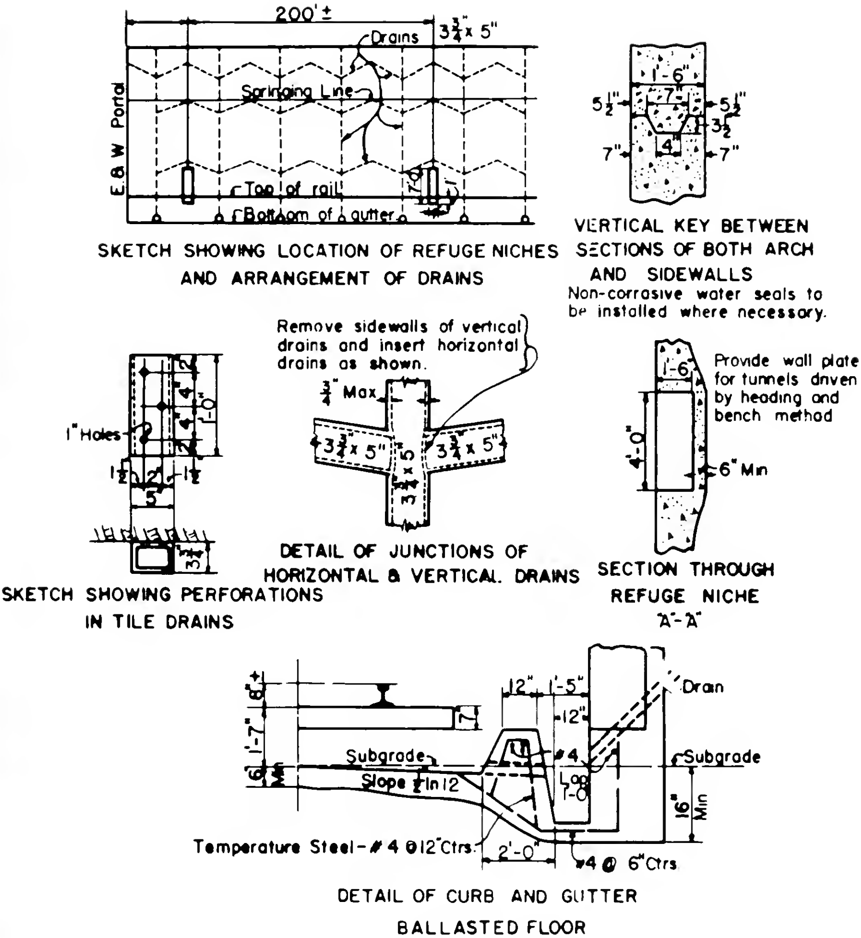
SINGLE TRACK, SOLID FLOOR



DOUBLE TRACK, SOLID FLOOR

PLAIN CONCRETE TUNNEL LINING

Fig. 1D - SOLID CONCRETE FLOOR DETAILS



PLAIN CONCRETE TUNNEL LINING

Fig. 1E – MISC. DETAILS

Manual Recommendations

Committee 31—Continuous Welded Rail

Report on Assignment 4

Maintenance

R. E. Gorsuch *(chairman, subcommittee)*, B. R. Forcier, R. G. Garland, W. J. Gilbert, R. S. Henry, B. R. Pruzak, J. R. Rymer, I. M. Simmons.

Your committee submits the following report for adoption and publication in the Manual.

RECOMMENDED FIELD REPAIRS TO PRESSURE BUTT WELD FAILURES

The following procedure is based on providing a proper rail temperature adjustment in accordance with local established requirements.

1. Repair by cutting in a short section of rail with the application of standard joint bars:

(a) Determine if a CWR temperature adjustment is necessary by consulting rail laying temperature records and other track condition data that may be available as a result of past track inspections or experiences.

(b) If necessary, proceed with the adjustment in accordance with standard practice.

(c) Promptly secure the CWR ends to prevent further movement. It is recommended that additional rail anchors be applied to the CWR ends for a sufficient distance to protect against rail-end movement in either direction.

(d) Saw cut the CWR, or flame cut if approved, on each side of the failed weld to obtain an opening for a short section of rail. It is recommended that the short rail be one-half the standard rail length to 36 ft long or at least 3 ft shorter than the standard length. If flame cut, the cut should be reasonably smooth. Smooth by polish grinding if necessary.

(e) Cut a rail to the desired length.

(f) Bevel all cut rail ends.

(g) Promptly place the short rail into the opening and spike it in place.

(h) Drill bolt holes of standard size. It is recommended that a templet be used to inscribe the bolt hole locations. Drilling through the joint bar holes is not recommended.

(i) Dress the edges of the bolt holes in accordance with standard practice.

(j) Install standard joint bars fully bolted.

(k) Adjust the rail anchor pattern to conform with standard practice.

(l) If in track circuit territory, install any necessary bond or connection wires.

(m) In a stretch of new rail, if the rail surface has not been sufficiently work hardened, it is recommended that all cut rail ends be end hardened at this time.

2. Repair by cutting in a short section of rail and thermite welding the rail ends:

(a) Proceed as outlined in paragraphs (a) through (e) above, except it is recommended that the short rail be at least 10 ft long or longer, preferably one-half the standard rail length.

(b) Promptly place the short rail into the opening, spiking it in place.

(c) Line up the rail ends to match, and block or wedge rail ends on each side of the joint sufficiently to maintain a good match for thermite welding.

(d) Proceed with thermite welding in accordance with standard practice. (See Thermite Welding—Rail Joints, Chapter 4 of the Manual, covering minimum requirements for making quality welds, good track alignment through the weld and satisfactory riding characteristics for thermite welded joints.)

(e) In cutting the opening for the short rail, the rail ends (joints) should fall in the center of a tie crib and/or ties moved as necessary for the free unobstructed application of the thermite weld mold.

(f) Adjust the rail anchor pattern to conform with standard practice.

(g) If in track circuit territory, install any necessary connection wires.

(h) If a CWR adjustment has been made or is not necessary but conditions do not permit thermite welding at the time, then drill the rail ends for the temporary use of standard joint bars with the exception of the first bolt holes of the rail ends. Omitting these holes will permit thermite welding later without further rail change. Adjust the rail anchor pattern to conform with standard practice for buffer rail. Follow with thermite welding as promptly as conditions permit.

If a CWR adjustment is necessary but conditions do not permit it at the time, it is recommended that thermite welding be postponed. Cut in a short plug rail of approved length. Drill all rail ends for the application of fully bolted standard joint bars. Adjust the rail anchor pattern to conform with standard practice for buffer rail. Follow with CWR adjustment and thermite welding as promptly as conditions permit.

General

(a) Before proceeding with repairs, thoroughly inspect the CWR and track condition for a sufficient distance to determine general track and rail condition, rail anchor performance, ballast condition, track alignment, rail tension or compression, etc. Any condition found warranting correction should be corrected at that time or the necessary safeguards taken to provide for the safe movement of trains until it is corrected.

Manual Recommendations

Committee 14—Yards and Terminals

Report on Assignment 2

Scales Used in Railway Service

F. D. Day *(chairman, subcommittee)*, R. P. Ainslie, J. K. Aust, R. F. Beck, A. E. Biermann, H. E. Buchanan, E. W. Buckles, C. M. Burnette, G. P. Burns, G. H. Chabot, J. F. Chandler, J. A. Comeau, E. H. Cook, J. L. Dahlrot, A. V. Dasburg, P. J. DeIvernois, V. H. Freygang, G. F. Graham, I. M. Hawver, A. L. Hunter, C. F. Intlekofer, D. B. Kendall, J. B. Kerby, A. S. Krefting, C. J. Lapinski, V. L. Ljungren, J. G. Martin, B. H. Price, A. E. Robinson, R. J. Samoska, C. W. Silver, C. E. Stoecker, K. D. Tidwell, L. G. Tieman, H. Watts, Jr., D. W. Wessels.

You· committee submits the following report for adoption and publication in Part 5, Chapter 14, of the Manual.

DEFINITION OF A STANDARD TEST OF A MOTION WEIGHING RAILWAY TRACK SCALE

1. Introduction

This procedure is to be used in the testing of scales required for the motion weighing of railroad cars. All calibration and adjustments will have been completed prior to any of this procedure. It should be recognized that weights obtained from any motion weighing scale or system may differ from those obtained on a static scale. The reasons for the weight variances are many and complex and will depend, among other things, upon the condition of the equipment weighed and the manner in which the equipment is handled.

There are three basic types of scale in use:

A. Single draft scales.

The car is weighed when all the car wheels are on the weigh rails. Except for such special cases where all cars being weighed are the same coupled length, this type scale is generally limited to uncoupled-in-motion weighing of individual cars.

B. Two draft scales.

The two ends of a car are weighed separately. The two weights obtained are added to produce a gross weight for the car. This type scale is used for uncoupled-in-motion and coupled-in-motion weighing.

C. Axle load scales.

Each axle of the car is weighed separately. The weights obtained are added to produce the gross weight of the car. The scale can weigh any vehicle having standard railway freight car trucks, either coupled or uncoupled-in-motion.

The motion weighing scales may be entirely automatic and unattended.

2. Test Equipment

Any of the following, or combination of the following, test equipment may be used:

A. Standard test weigh cars meeting the specifications of Section CC of the AREA–AAR Handbook SCALES (Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales). The cars may be of different weights.

B. Cars equipped with standard freight car trucks and with devices to support the entire load on pedestals or special axles. If possible, the entire weight of the test car should be placed on the scale. The car must have been certified to a definite weight and may have provisions for carrying and removing calibrated test weights. The car may be self-propelled.

C. Railway cars equipped with standard freight car trucks and certified as Standard Weights.

D. Railway cars weighed as described below and assigned a reference weight value.

(1) The cars should have a range of gross weights similar to the weights of cars used in the normal operation of the scale.

(2) The cars should be free of defects. The test shall not be conducted or continued if rain, snow or other unusual conditions alter or affect the weights of the cars before the motion test is completed.

(3) When loaded cars are used, the contents of the lading should be stable.

(4) The reference weight value shall be obtained by comparison, preferably from a single draft scale.

(5) The static scale shall be tested as specified in the AREA–AAR Handbook SCALES, Section C (Definition of a Standard Test of a Static Railway Track Scale), using test equipment 2A, 2B or 2C.

(6) In addition to the usual test, the scale shall be strain tested if possible, by using a loaded railway freight car and a scale test car. The loaded car is weighed on the static scale. A scale test car is placed on the scale with the loaded car, or test weights are used in lieu of the test car, so that the entire loading is scale borne. The deviation in the weight obtained for the loaded car plus the test equipment shall be as near as possible to zero, but must not exceed the two tenths percent of the applied test load.

3. Test Procedure

A. Single draft scale uncoupled-in-motion test.

(1) The car speed and the direction of travel shall be the same as it will be when the scale is in normal use. The following procedure shall be used:

With the test equipment as per 2.A, 2.B, 2.C and/or 2.D each car is moved over the scale five times.

B. Two draft scale uncoupled-in-motion or coupled-in-motion test.

(1) The uncoupled-in-motion test shall be as per 3.A, excluding 2.A test equipment

(2) The coupled-in-motion test

(a) The scale shall be tested in the manner in which it will be operated, that is with the locomotive either pushing or pulling the cars at the designed speed and in the proper direction. Ten cars should be used for testing, if practical, employing test equipment as per 2.B, 2.C and/or 2.D.

(b) The following procedure shall be used:
The train of coupled test cars is moved over the scale a sufficient number of times to secure or produce 100 motion weights, if practical.

C. Axle load scales.

(1) The uncoupled-in-motion test shall be as per 3.A, excluding 2.A test equipment.

(2) The coupled-in-motion test shall be as per 3.B.(2).

4. Tolerances

A. Acceptance Test tolerances.

(1) The static vs. the motion gross weight in the uncoupled-in-motion test of a single car shall not exceed plus or minus one tenth of one percent of the applied test load plus one half the smallest operating read-out value of the scale.

(2) The sum of the static vs. the sum of the motion gross weights of the test train in a coupled-in-motion test shall not differ by more than one tenth of one percent.

B. Maintenance Test tolerances.

(1) The static vs. the motion gross weight in the uncoupled-in-motion test of a single car shall not exceed plus or minus two tenths of one percent of the applied test load plus one half the smallest operating read-out value of the scale.

(2) The sum of the static vs. the sum of the motion gross weights of the test train in a coupled-in-motion test shall not differ by more than two tenths of one percent

Individual car weights shall not be considered.

5. Frequency of tests.

A. A maintenance test using the procedure in paragraph 3. shall be made at least once a year.

B. Motion weighing scales, particularly electronic scales during the first several months after acceptance, shall be frequently monitored to assure proper performance. Reference weight cars may be used for this monitoring.

Manual Recommendations

Committee 20—Contract Forms

Revision of Manual

The following proposed new Section 8. Liability in Connection with Sidetrack of the Form of Agreement for Industry Track, Chapter 20, pages 20–4–8 and 8.1, was developed by the Legal Affairs Committee of the Association of American Railroads and the National Industrial Traffic League, approved by both those bodies, and submitted to the AREA for consideration of adopting for the AREA Manual. Committee 20 has reviewed the proposed Section 8 and the Section is published herein for adoption to supersede the present Section 8.

8. Liability in Connection with Sidetrack*

(a) *Fire.* The Industry assumes all responsibility for and shall indemnify, hold harmless and defend the Railroad Company from and against loss or damage to property of the Industry or to property upon the premises of the Industry or upon said sidetrack arising from fire caused by the mechanical operation of locomotives or the movement of rolling stock while serving Industry, including expenses and attorneys' fees, regardless of whether or not said loss or damage is caused, in whole or in part, by the actionable negligence of the Railroad Company, its agents or employees; provided, however, that the Industry shall have no responsibility to indemnify the Railroad Company for loss or damage by fire as aforesaid to the property of the Railroad Company, or to locomotives and rolling stock belonging to the Railroad Company or to third parties, or to shipments then in the common carrier custody of the Railroad Company, unless such loss or damage is caused by actionable negligence on the part of the Industry, its agents or employees.

(b) *Other Liability.* Except as herein otherwise specifically provided, in respect of all loss or damage to property (other than by fire as aforesaid) and/or in respect of injury to or death of persons caused by or in connection with the construction, operation, maintenance, use, presence or removal of said sidetrack, as between the parties hereto:

(i) the Railroad Company shall assume responsibility for and hold the Industry harmless and defend the Industry from all losses (including claims for injuries to employees of the Industry or of the Railroad Company), expenses, attorneys' fees, damages, claims and judgments arising from or growing out of the actionable acts or omissions of the Railroad Company, its agents or employees, solely or in conjunction with a third person;

(ii) the Industry shall assume responsibility for and hold the Railroad Company harmless and defend the Railroad Company from all losses (including claims for injuries to employees of the Industry or of the Railroad Company), expenses, attorneys' fees, damages, claims and judgments arising from or growing out of the actionable acts or omissions of the Industry, its agents or employees, solely or in conjunction with a third person;

(iii) the parties hereto shall equally bear all losses (including claims for injuries to employees of the Industry or of the Railroad Company), expenses, attorneys' fees, damages, claims and judgments arising from or growing out of the joint or concurring actionable acts or omissions of both parties hereto, their respective agents or employees; and

(iv) notwithstanding anything contained in this Section 8(b), and irrespective of any joint or concurring negligence of the Railroad Company, the Industry assumes sole responsibility for and agrees to indemnify, save harmless and defend the Railroad Company from and against all claims, actions or legal proceedings arising, in whole or in part, from the failure of the Industry to comply with clearance requirements set forth in Section 7 hereof; provided, however, that knowledge on the part of the Railroad Company of a violation of the clearance requirements of Section 7, whether such knowledge is actual or implied, shall not constitute a waiver and shall not relieve the Industry of its obligation to indemnify the Railroad Company for losses and claims resulting from any such violation.

*Note: The language in paragraph 8 was the subject of discussion with The National Industrial Traffic League which regards the language as providing useful guide lines in formulating any final agreements on this subject matter between individual shippers and railroads.

Manual Recommendations

Committee 5—Track

Report on Assignment 5

Turnout and Crossing Design

C. J. McConaughy *(chairman, subcommittee)*, G. B. Boggs, W. G. Crone, A. G. Ellefson, E. E. Frank, V. C. Hankins, D. L. Jerman, R. J. Jones, C. N. King, G. G. Knupp, R. E. Kuston, J. R. Masters, M. P. Moore, G. H. Perkins, G. Perko, C. E. Peterson, L. E. Porter, A. J. Schavet, K. H. von Kampen, E. R. Wiltz.

Your committee submits the following plans for adoption and publication in the Portfolio of Trackwork Plans:

Plan No. 600A–72, Design Criteria for Railbound Manganese Steel Frogs.

Plan No. 746 –72, Manganese Steel Insert Crossings, Angles 90° to 70° incl.

Plan No. 747 –72, Manganese Steel Insert Crossings, Angles Below 70° to 60° incl.

Plan No. 748 –72, Manganese Steel Insert Crossings, Angles Below 60° to 45° incl.

Plan No. 749 –72, Designs and Dimensions of Manganese Steel Inserts for Crossings of Angles 90° to 45° incl.

Prints of the above plans are presented herewith.

DESIGN CRITERIA FOR RAILBOUND
MANGANESE STEEL FROGS

Applicable to All Frogs from No. 4 to No. 20 Inclusive
Plans 611 thru 615

1. Heel

The heel end of manganese point is placed where the spread between gage lines is 4-3/4 in.

2. Heel Block Extension

The heel block extension running out from the heel of manganese point between the heel rails to be 23 in. long for frogs No. 4, 5, and 6 and 26 in. long for No. 7; above No. 7, the heel extension is to run 6 in. beyond the point where spread between gage lines is 7-1/4 in. The heel block extension is integral with the manganese body casting on all frogs up to and including No. 15; for frogs No. 16 to No. 20, inclusive, the integral part is made 10-1/2 in. long from the heel of manganese point and a separate heel block casting forms the balance. The riser at the end of all heel blocks is to have a slope from 1/2 in. below the level of the head rails at the end to tread level in a length of 6 in.

3. Heel Rails

The heel rails are offset horizontally toward the gage line by a short bend at the end of the heel block extension and a reverse bend 15-1/2 in. from the point end of the rails on all frogs up to and including No. 12, 22 in. for frogs No. 14 and 15, and 27 in. from the point end of the rail for frogs No. 16 and 18 and 33-1/2 in. for No. 20, so as to bring the center line of web 7/8 in. (± 1/16 in.) or 1 in. (± 1/8 in.) for rail head 2-3/4 in. or greater (from gage line of frog and running parallel to gage line from point end to reverse bend. Head on gage line is planed to straight line conforming to side contour of head. Back of head is planed to a straight taper with a vertical side from 1-1/2 in. net width of head at point to full section at end of heel block extension.

The point end of rail is cut at an angle of 45 deg. to the gage line and the back of head at point end is rounded by 5 in. radius.

4. Wing Rail

Wing rail laps heel rail from point end to 1 in. beyond reverse bend or for a length of 16-1/2 in. for all frogs up to and including No. 12, 23 in. for frogs No. 14 and 15 and 28 in. for No. 16 and 18 and 34-1/2 in. for No. 20, and is parallel to gage line with a width of flangeway of 2-1/4 in. using a standard section filler made for a 1-7/8 in. flangeway with full rail heads, but producing a width of 2-1/4 in. between the line of head of wing rail and the planed away head of heel rail. The side of the head of wing rail is planed for a straight flare on the guard side running on a line from the 2-1/4 in. flangeway opening at the end of the manganese wing to a 3-1/2 in. flare opening at the end of the flare measured 5/8 in. below tread level. The side of flare planing on the wing rail commencing at the end of the manganese wing to be on a bevel of 25 deg. from vertical. The location of the 2-1/4 in. flangeway opening is shown on the individual frog plans.

Where the flare line intersect, the side of the head of wing rail at the 2-1/4 in. width of flangeway measured 5/8 in. below tread level, head of wing rail is notched to a radius of 5/8 in. for the reception of the manganese steel wing and rail is bent outward on a straight line from 1-1/2 in. ahead of the notch so as to bring side of full head 4 in. from gage line opposite theoretical point. Opposite theoretical point wing rail is bent back on a line running to a gage line toe spread of 3 in., but on an angle of not less than 1 in 8 with gage line (frogs No. 4 to No. 10, inclusive). If angle comes out smaller than 1 in 8, reduce toe spread (2.91 in. for No. 11 frog and 2.67 in. for No. 12 frog) to make the angle 1 in 8 until a minimum toe spread of 2-1/2 in. is reached (frogs No. 14 to No. 20, inclusive) when such minimum spread and minimum angle of 1 in 8 are kept and the middle bend of wing rail moved toward the toe end of the frog by extending the line of wing rail running from the notch to the point 4 in. out at theoretical point until such line meets the line drawn from 2-1/2 in. toe spread on the 1 in 8 angle. Head is planed with vertical side from notch to full section of head at middle bend.

5. Manganese Steel Body and Wings

From the heel end of the manganese point at the 4-3/4 in. spread the manganese is carried across the flangeway on an angle of 30 Deg. to the gage line to the web of the wing rail. It then follows the web of bent wing rail to the bend at toe, where the manganese body ends. The back of the manganese wing fits into the notch in the wing rail and follows the planed and bent head of the wing rail to the toe end, where it lies up against the side of the full head section of the wing rail, the end being sloped and rounded. Manganese wing is flared to follow flare line of planed flare in wing rail from 2-1/4 in. opening at notch to 1-7/8 in. width of flangeway. Bottom bearing of the manganese steel casting on top of base of wing rail to be continuous throughout except at bends. Bearing under head and against web of wing rail to be 3 in. long at every other through bolt commencing with the second bolt from the manganese heel towards the toe down to the first bolt from the theoretical point towards the heel and then at every bolt to the toe end; and for a length of 4 in. at the last bolt through the toe end of manganese body.

Heel extension to have continuous bearing on the top of base of heel rails and to bear against the web and under head continuous from the point end of heel rails for same length as flangeway filler, then for 3 in. at each bolt beyond end of filler and 4 in. at end of heel block extension.

6. Fillers and Toe Blocks

Fillers between heel rails and wing rails are of a constant length of 16-1/2 in. for frogs No. 4 to No. 12 inclusive, and 23 in. for frogs No. 14 and 15, 28 in. for frogs No. 16 and 18 and 34-1/2 in. for frog No. 20 measured on gage line, being cut square on the inner end and beveled to match end of wing rail on the outer end.

Toe blocks are placed 2 in. from the toe end of the manganese body and are 7 in. long, with one bolt for all frogs up to and including No. 15, and 12 in. long with two bolts for frogs No. 16 to No. 20 inclusive.

7. Bolt Spacing

At heel end spacing of bolts through heel rails, wing rails and fillers is constant; 3 in. -5 in. - 5 in., for all frogs from No. 4 to No. 12 inclusive, and 3 in. -5 in. - 5 in. - 6-1/2 in. for frogs No. 14 and 15; 3 in. -5 in. - 5 in. - 6-1/2 in., for frogs No. 16 & 18, and 3 in. - 5 in. - 5 in. -5 in. - 6-1/2 in. - 6-1/2 in. for frog No. 20 inclusive measured on gage line from point end of heel rail. Bolt at end of heel block extension is placed 2 in. from extreme end of all frogs. In 26 in. long heel block extension one additional bolt is placed midway between end bolt and last bolt through filler (No. 7 and No. 8 frogs). In longer extensions (frogs No. 9 thru No. 12) first bolt outside of end of wing rails is placed 6-1/2 in. from last bolt through flangeway fillers and an additional bolt is spaced between this bolt and the end bolt for frogs No. 11 and No. 12, for frog No. 14 thru No. 20 the bolts outside of end of wing rails are spaced between the last bolt thru flangeway filler and end bolt in equal spaces not exceeding 11-1/2" c. to c. At toe end position of bolts through the block is constant being 6 in. measured on gage line from toe end of manganese body for 7 in., 8 in. and 10 in. toe blocks and 4 in. - 8 in. for 12 in. toe block, foot guard blocks beyond toe blocks and heel block extension to have bolts spaced as shown on plans. Position of first two bolts through manganese body at toe end is constant 2 in. - 7 in. for all frogs, measured on gage line from toe end of casting. Body bolts between fixed position of bolts at heel and toe ends are spaced in least number of equal spaces not exceeding 12 in. from c. to c.

INDEX TO DETAIL PLANS

FROG NO	PLAN NO.
4	611
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FROG NO.	PLAN NO.
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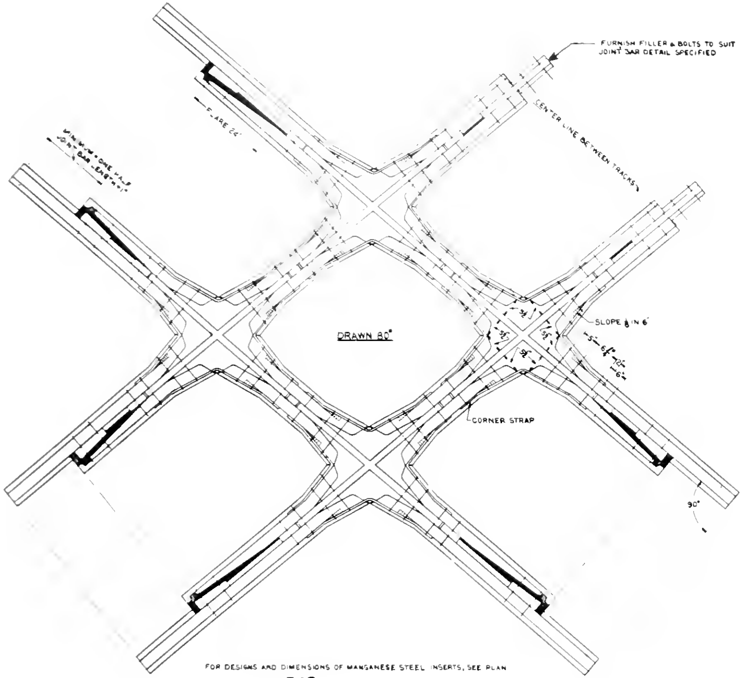
12	614
14	614
15	614
16	615
18	615
20	615

American Railway Engineering Association

DESIGN CRITERIA FOR RAILBOUND MANGANESE STEEL FROGS

TENTATIVE **PLAN NO. 600-A-72**



FOR DESIGNS AND DIMENSIONS OF MANGANESE STEEL INSERTS, SEE PLAN BASIC No. 749

LENGTH OF END FROG ARMS - 6'-0"

NOTES

1—RAIL AND JOINT BARS: Purchaser shall specify weight and designation of rail section and joint drilling and shall supply complete details of joint bars. Location of insulated joints in the crossing plate area shall be designated.

2—Unless otherwise specified, crossing shall be furnished as illustrated and to the following details:
- (a) BOLTS. Sizes and details of all through bolts shall be per Section 1402, Appendix "A". All special length joint bolts shall be furnished.
- (b) PLATES. Continuous and Filler Plates Style 1 and Special Tie Plates per Plan Basic No. 700F, designed to suit tie layout shown thereon.
- (c) FILLERS. Flangeway filler shall be of rolled steel, per Plan Basic No. 325, and shall maintain the required flangeway throughout. Spacer blocks may be of cast iron.
- (d) CORNER STRAPS. Shall be of rolled steel 1 1/2" thick and shaped to fit closely into the fishing space of the rails.
- (e) INTERTRACK CONNECTIONS. Guarding shall be continuous between crossings, except that when distance permits, flared guards as shown for the external arms are furnished. Continuous guarding shall also be furnished for the inside rail when required by curvature. Arm lengths are preferably designed with a single joint between crossings, but if this requires lengths that cause excessive shipping and installation difficulties, separate closure rails not less than 10'0" long shall be furnished. Purchaser shall provide full length 39'0" rails when required. Select arm lengths where possible to permit supported or suspended joints.

3—ALTERNATES. To be furnished when specified:
- (a) DEPTH HARDENING. Impact areas to be depth hardened per Section 410, Appendix "A".
- (b) Other design of plates and/or tie layouts per details supplied by purchaser. See Note 4, Plan Basic No. 700F.
- (c) Continuous guarding between crossings where flared guards are permitted by Note 2(e).

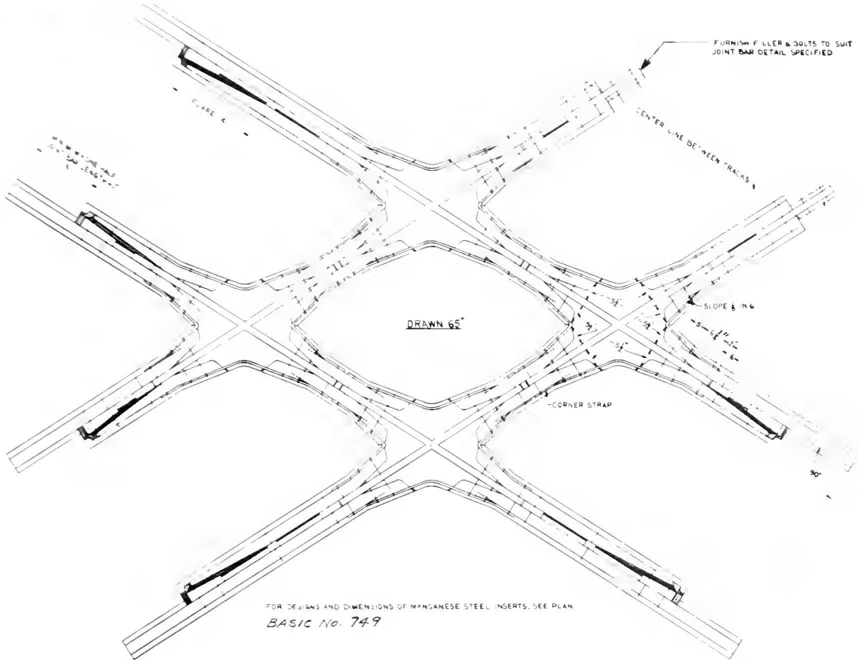
4—GENERAL REFERENCES.
- (a) For application of AREA crossing designs and recommended practice, see Plan Basic No. 700.
- (b) Gages and widths of flangeways for tangent track per Plan Basic No. 790, and for curved track per Plan Basic No. 791. For permissible variations in manufacture, see Section 33, Appendix "A".
- (c) FLARES. See Plan Basic No. 350 for details.
- (d) BEVELING. See Plan Basic No. 1005 for beveling of running rail ends.

5— SPECIFICATIONS. See Appendix "A".

American Railway Engineering Association

MANGANESE STEEL INSERT CROSSINGS
ANGLES 90° TO 70° INCL.

Tentative Plan No. 746-72



LENGTH OF END FROG ARMS

Below 70° to 65° INCL - 6'-0"
" 65° to 60° INCL - 6'-6"

NOTES

1—RAIL AND JOINT BARS: Purchaser shall specify weight and designation of rail section and joint drilling and shall supply complete details of joint bars. Location of insulated joints in the crossing plate area shall be designated.

2—Unless otherwise specified, crossing shall be furnished as illustrated and to the following details:
- (a) BOLTS. Sizes and details of all through bolts shall be per Section 1402, Appendix "A". All special length joint bolts shall be furnished.
- (b) PLATES. Continuous and Filler Plates Style 1 and Special Tie Plates per Plan Basic No. 700P, designed to suit tie layout shown thereon.
- (c) FILLERS. Flangeway filler shall be of rolled steel, per Plan Basic No. 325, and shall maintain the required flangeway throughout. Spacer blocks may be of cast iron.
- (d) CORNER STRAPS. Shall be of rolled steel 1 1/2" thick and shaped to fit closely into the fishing space of the rails.
- (e) INTERTRACK CONNECTIONS. Guarding shall be continuous between crossings, except that when distance permits, flared guards as shown for the external arms are furnished. Continuous guarding shall also be furnished for the inside rail when required by curvature. Arm lengths are preferably designed with a single joint between crossings, but if this requires lengths that cause excessive shipping and installation difficulties, separate closure rails not less than 10'0" long shall be furnished. Purchaser shall provide full length 39'0" rails when required. Select arm lengths where possible to permit supported or suspended joints.

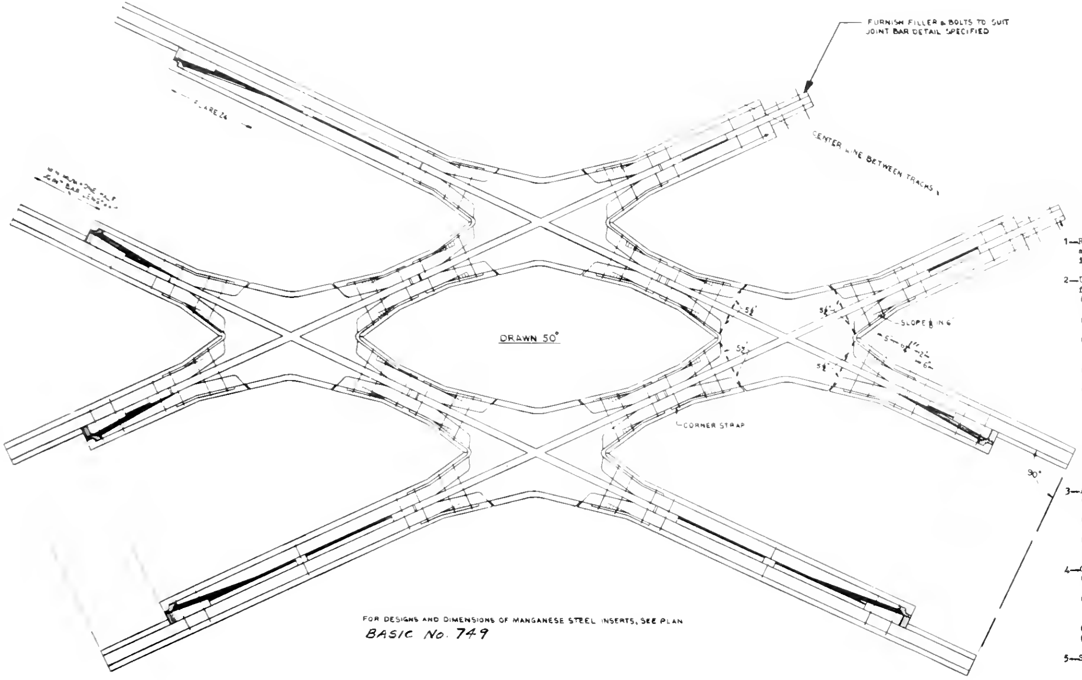
3—ALTERNATES. To be furnished when specified:
- (a) DEPTH HARDENING. Impact areas to be depth hardened per Section 410, Appendix "A".
- (b) Other design of plates and/or tie layouts per details supplied by purchaser. See Note 4, Plan Basic No. 700P.
- (c) Continuous guarding between crossings where flared guards are permitted by Note 2(e).

4—GENERAL REFERENCES.
- (a) For application of AREA crossing designs and recommended practice, see Plan Basic No. 700.
- (b) Gages and widths of flangeways for tangent track per Plan Basic No. 790, and for curved track per Plan Basic No. 791. For permissible variations in manufacture, see Section 33, Appendix "A".
- (c) FLARES. See Plan Basic No. 350 for details.
- (d) BEVELING. See Plan Basic No. 1005 for beveling of running rail ends.

5— SPECIFICATIONS. See Appendix "A".

American Railway Engineering Association

MANGANESE STEEL INSERT CROSSINGS
ANGLES BELOW 70° TO 60° *INCL.*
Tentative Plan No. 747-72



NOTES

1—RAIL AND JOINT BARS: Purchaser shall specify weight and designation of rail section and joint drilling and shall supply complete details of joint bars. Location of insulated joints in the crossing plate area shall be designated.

2—Unless otherwise specified, crossing shall be furnished as illustrated and to the following details:
- (a) BOLTS. Sizes and details of all through bolts shall be per Section 1402, Appendix "A". All special length joint bolts shall be furnished.
- (b) PLATES. Corner Plates Style 3 and Special Tie Plates per Plan Basic No. 7000 designed to suit tie layouts, shown thereon.
- (c) FILLERS. Flangeway filler shall be of rolled steel, per Plan Basic No. 325, and shall maintain the required flangeway throughout. Spacer blocks may be of cast iron.
- (d) CORNER STRAPS. Shall be of rolled steel 1 1/2" thick and shaped to fit closely into the fishing space of the rails.
- (e) INTERTRACK CONNECTIONS. Guarding shall be continuous between crossings, except that when distance permits, flared guards as shown for the external arms are furnished. Continuous guarding shall also be furnished for the inside rail when required by curvature. Arm lengths are preferably designed with a single joint between crossings, but if this requires lengths that cause excessive shipping and installation difficulties, separate closure rails not less than 10'0" long shall be furnished. Purchaser shall provide full length 39'0" rails when required. Select arm lengths where possible to permit supported or suspended joints.

3—ALTERNATES. To be furnished when specified:
- (a) DEPTH HARDENING. Impact areas to be depth hardened per Section 410, Appendix "A".
- (b) Other design of plates and/or tie layouts per details supplied by purchaser, See Note 4, Plan Basic No. 700G.
- (c) Continuous guarding between crossings where flared guards are permitted by Note 2(e).

4—GENERAL REFERENCES.
- (a) For application of AREA crossing designs and recommended practice, see Plan Basic No. 700.
- (b) Gages and widths of flangeways for tangent track per Plan Basic No. 790, and for curved track per Plan Basic No. 791. For permissible variations in manufacture, see Section 33, Appendix "A".
- (c) FLARES. See Plan Basic No. 350 for details.
- (d) BEVELING. See Plan Basic No. 1005 for beveling of running rail ends.

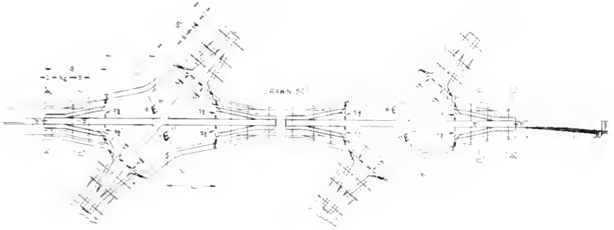
5—SPECIFICATIONS. See Appendix "A".

LENGTH OF END FROG ARMS

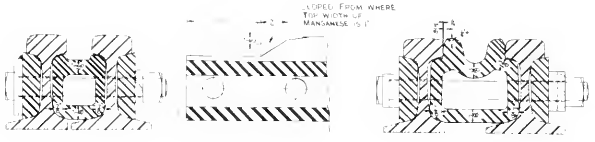
Below 60° TO 50° INCL - 6'-6"
" 50° TO 45° INCL - 7'-0"

American Railway Engineering Association

MANGANESE STEEL INSERT CROSSINGS
ANGLES BELOW 60° TO 45° INCL.
Tentative Plan No. 748-72

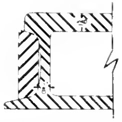


BELOW 60° TO 45° INCL

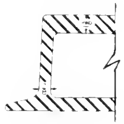


SECTION A-A SECTION B-B SECTION C-C

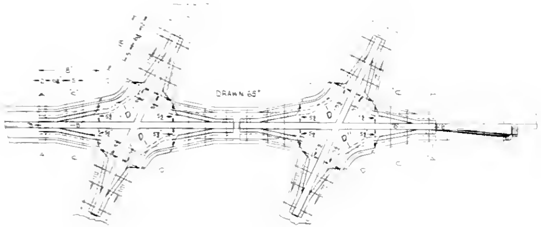
NOTE - MINIMUM WALL & FLOOR THICKNESS $\frac{7}{8}$"



PARTIAL SECTION D-D



PARTIAL SECTION E-E



BELOW 70° TO 60° INCL

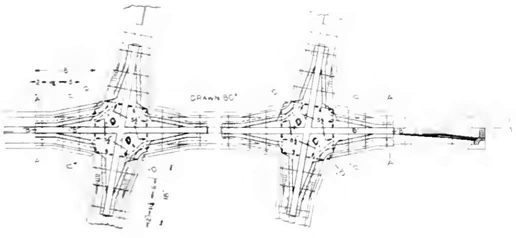
NOTES

1 - REINFORCEMENT. Portions of Castings at intersections shall be thoroughly and efficiently reinforced.

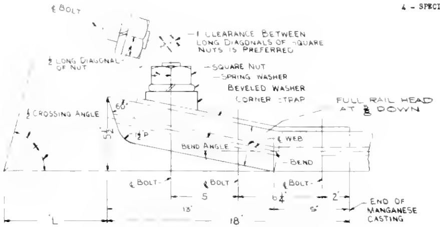
2 - FLANGEWAY DIMENSIONS. See plan basic No. 600B for contours of flangeways and rounding of flangeway walls at intersections.

3 - BOLTS. Sizes and details of all through bolts shall be per Section 1402, Appendix "A".

4 - SPECIFICATIONS. See Appendix "A".



90° TO 70° INCL



DETAIL FOR RAIL BENDING AND NUT CLEARANCE

American Railway Engineering Association

DESIGNS AND DIMENSIONS OF MANGANESE STEEL INSERTS FOR CROSSINGS OF ANGLES 90° TO 45° INCL.

Tentative Plan No. 749-72

Assure lower maintenance costs, better performance with

Texaco Railroad Lubricants and Systematic Engineering Service

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Racine Plate-Boy quickly pays for itself by reducing the cost of cleaning ballast from ties and inserting the tie plates.

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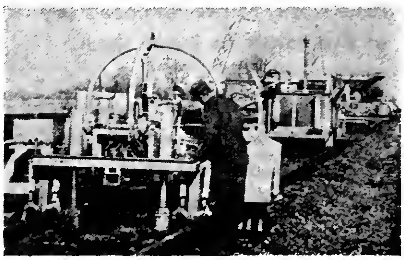

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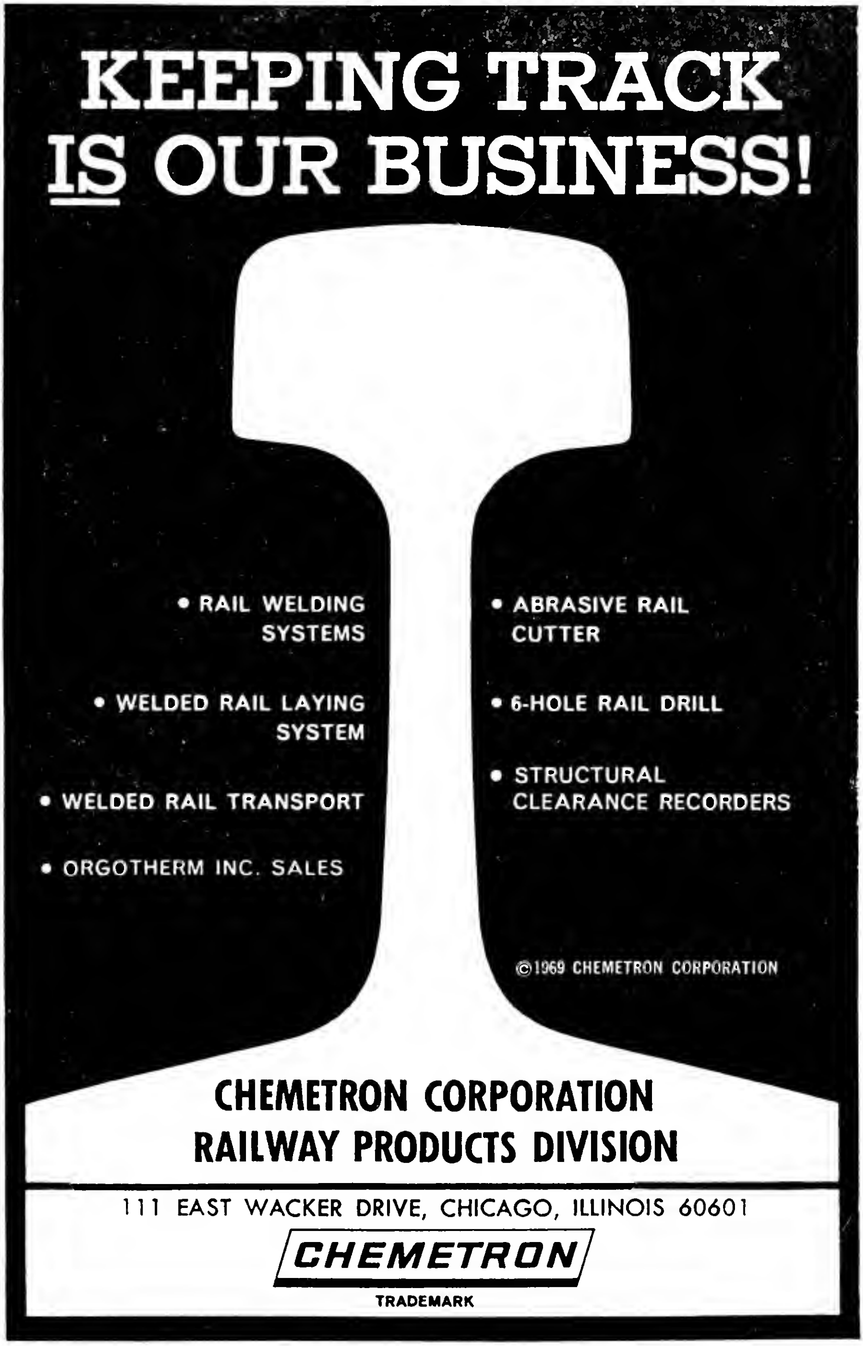
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CHEMETRON
TRADEMARK

Patent Numbers: 3,102,690;
3,118,327;
3,159,198.

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SEALTITE DOME HEAD DRIVE SPIKE

Fastens timbers and plank decking on grade crossings, bridges and docks. Wide, smooth head seals opening, wears well.

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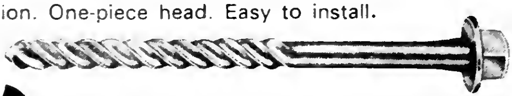
Fastens highway crossing planks, bridge guard rails and general timber construction. One-piece head. Easy to install.



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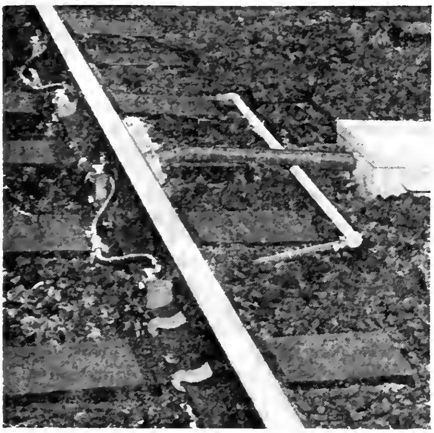
M & S No. 561 GREASE TYPE LUBRICATOR

OVER 1800 IN SERVICE



The M & S No. 561 Grease Type Lubricator is simple in design, durable in construction and efficient in operation. It was designed, developed and tested to meet modern railroad conditions where maintenance costs on equipment of this nature must be held to an absolute minimum.

This Grease Type Lubricator was designed and developed by Moore & Steele Corporation, a company which has been actively engaged in developing and manufacturing rail and flange lubricators since 1932. The M & S No. 561 Grease Type Lubricator incorporates the time and service tested principles developed during 40 years experience in the field of rail lubrication.

ALSO MADE IN DOUBLE RAIL MODEL

MOORE AND STEELE CORPORATION

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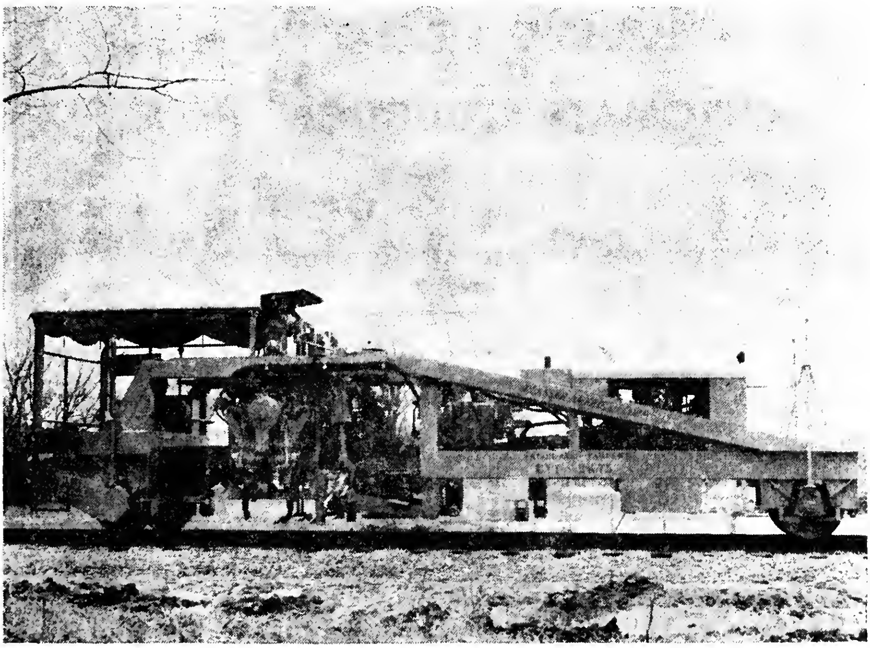
SWITCH TAMPERS FOR ALL YOUR JOBS

UNIVERSAL UYT-2W75 YARD, SWITCH & SPOT TAMPER

This versatile tamper is a new addition to the popular Plasser Universal line. Even though the UYT 2W75 has a lower original cost, it is equipped with two of the exclusive Plasser four-tool tamping heads with individually tiltable tamping arms, which insures the tamping of every tie through switches and turnouts without the use of outside or ground jacks.



This Universal UYT 2W75 tamper is particularly adaptable for yard work where it has proven itself as a money saver. The reasonable price plus its ability to do a fine job tamping switches and doing spot work suggest yard assignment. It can be equipped with automatic lifting and leveling equipment as well as automatic lifting correction with cross level indicator. You should see one of these tampers in service and we will be pleased to make the necessary arrangements for you to do so at your convenience. You will be convinced that it is a superior machine.

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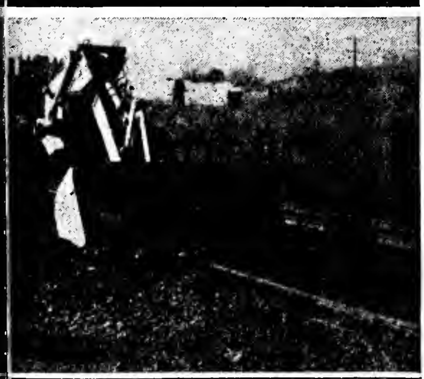

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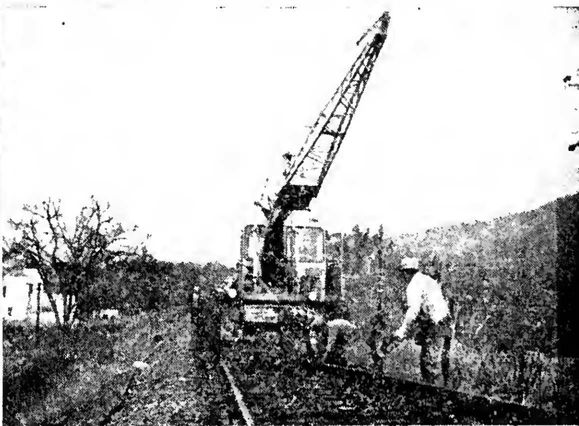

LAYING STANDARD RAIL

CUTS MAINTENANCE COSTS

12 FAST CHANGE ATTACHMENTS

- Forks
- 1¼ Cu. Yd. Bucket
- Tote Hook
- 18' Boom Extension
- Fork Tie Baler
- Track Cleaning Bucket
- Back Hoe
- Clamshell
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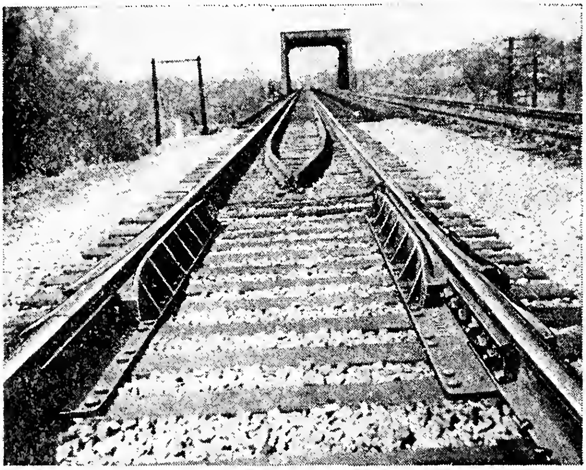
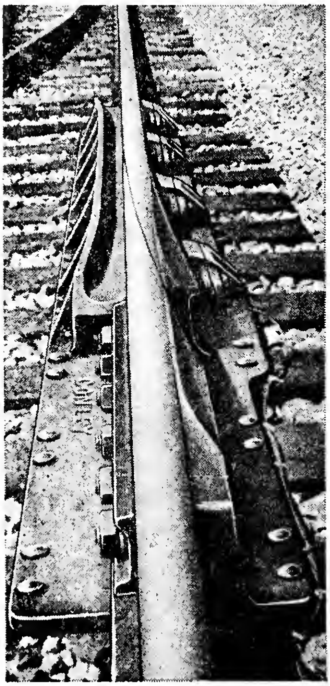


Meet the sliding rail



. . . that will prevent buckling, pull-aparts, and other problems caused by rail expansion and contraction!

In addition, each Conley Sliding Rail is designed to meet *specific* track conditions. Each is completely automatic and temperature-controlled. And its heavy base (approx. 2,400 lbs.) assures solid foundation and rugged, long-lasting dependability.

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Conley

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Conley Frog and Switch Co.

Box 9188 / Memphis, Tennessee 38109

PART 2

REPORTS OF COMMITTEES

Note: Discussion on subcommittee reports herein closes on January 22, 1973.

Report of Committee 9—Highways

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Chairman
C. A. Christensen,
Vice Chairman

L. T. Cerny, ***Secretary***
J. E. Spangler
C. L. Holman
R. A. Downey
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W. B. Calder
A. L. Carpenter
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F. Daugherty
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C. I. Hartsell
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J. A. Holmes
E. E. Howard
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P. G. Jefferis, Jr.
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R. H. Patterson
W. C. Pinschmidt (E)
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H. A. Richards
C. W. Smith
R. F. Spars
J. R. Summers
J. M. Trissal
H. J. Wilkins
H. L. Woltman
C. H. Worboys
Committee

(E) Member Emeritus.

Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.
Progress report on proposed revisions submitted as information ...... page 158

1. Roadbed Stabilization for Highway–Railway Grade Crossings.
No report for past year's activity.

2. Merits and Economics of Prefabricated Types of Highway–Railway Grade Crossings.
Progress report on concrete slab crossings and prefabricated rubber crossings submitted as information .... page 159

3. Summary Reporting of Significant Publications on Grade Crossing Safety.
Summarized reports submitted as information .... page 161

4. Evaluation of Developments in Passive and Non-Train-Actuated Grade Crossing Protection.
Progress report submitted as information .... page 167

5. Study of Motor Vehicle Codes and Drivers' Licensing Practices.
Progress report submitted as information .... page 168

6. Air Rights for Highways Over Railroad Property.
   No report for past year's activity. The Highway Research Board project, "Valuation of Air Space," has been completed and a report will be made on this subject next year.

7. Evaluation of Developments in Train-Actuated Grade Crossing Protection.
   No report for past year's activity.

8. Investigate Uses and Types of Rumble Strips and Their Adaptability for Approaches to Highway–Railway Grade Crossings.
   Progress report on rumble strip installation submitted as information .. page 169

9. Study of Public Pedestrian Crossings.
   Progress report submitted as information .... page 171

THE COMMITTEE ON HIGHWAYS,
K. E. WYCKOFF, *Chairman*.

Report on Assignment B

Revision of Manual

J. E. SPANGLER *(chairman, subcommittee)*, J. M. BATES, C. A. CHRISTENSEN, J. W. CRUIKSHANK, FINLEY DAUGHERTY, R. A. DOWNEY, C. I. HARTSELL, E. E. HOWARD, D. P. INSANA, P. G. JEFFERIS, JR., R. V. LOFTUS, R. F. MACDONALD, J. C. MILLER, R. E. SKINNER, J. M. TRISSAL, W. E. WEBSTER, JR., K. E. WYCKOFF.

Consideration has been given during the past year to a change in the specifications in Part 1 for the construction of wood plank crossings. In the tables showing recommended use on page 9–1–1, no distinction is now made in the use of Type "A" (full depth) prefabricated and wood plank crossings and Type "B" prefabricated and wood plank crossings, which use shims between the bottoms of the planks and the tops of the ties. The opinion has been advanced that Type "A" crossings are entirely suitable for heavy and medium traffic roads. A study of the use of this type of crossing in the standards of various railroads bears this out. It is, therefore, proposed that Type "A" and Type "B" crossings be given a separate reference number on page 9–1–1, and that the full-depth crossings be recommended for use in heavy and medium traffic highways. This handling will be pursued, with the intention of putting the matter to vote among the committee membership before the submission of the Committee 9 report in September 1973.

The committee has also investigated the possible revision of certain segments of Parts 2, 3, and 4 of the Manual. This was extensively discussed in the June 1972 meeting, as a result of which specific recommended revisions were prepared. These revisions were to be made concurrently with changes in Bulletin 6, being considered by the AAR Signal Liaison Committee. When it was determined that no immediate action was to be taken by that committee, the decision was made to defer the circulation of a ballot in time for the 1972–1973 Committee 9 report.

However, it is felt that certain changes in Parts 2 and 3 of the Manual can be considered at this time, irrespective of the action of the Signal Liaison Committee. We, therefore, recommend that these changes be covered in a ballot this fall (1973), since they are not considered to be tied in closely with specifications of Bulletin 6.

This report is submitted as information.

Report on Assignment 2

Merits and Economics of Prefabricated Types of Highway–Railway Grade Crossings

R. A. Downey *(chairman, subcommittee)*, W. A. Buckmaster, W. B. Calder, L. T. Cerny, C. A. Christensen, J. W. Cruikshank, T. P. Cunningham, C. I. Hartsell, W. J. Hedley, J. A. Holmes, E. E. Howard, R. V. Loftus, D. G. Newnan, P. A. Shuster, C. W. Smith, W. E. Webster, Jr., K. E. Wyckoff.

INSPECTION OF NEW-DESIGN CONCRETE SLAB CROSSINGS IN VICINITY OF DUSSELDORF, GERMANY

An inspection of concrete slab crossings of a design new to the United States was made by a subcommittee member on May 8 and 9, 1972, in the vicinity of Dusseldorf, Germany, escorted by Mathias Holthausen, inventor of the crossings. The design consists of a frame of used rails connected by rods, which is then filled in with reinforced concrete. The slabs rest on small bags filled with concrete which are placed (with the concrete in the bags still wet) on the crossties before the slabs are placed. This assures uniform bearing for the slabs. In European practice, the slabs are held in place by clips attached to the screws which attach the rail to the tie. The crossings appear to have given excellent service, with no significant wear or deterioration after eight years of service on a public road with heavy truck and bus traffic. The crossings can be ordered to fit curved track and switches. The installations of conventional switches in paved areas using these concrete slabs were smooth riding, even at switch points, with no maintenance of the crossing slabs in 10 years of service.

This type of crossing has just come on the market in the United States, modified for United States practice (due to not using screw spikes in the United States) by attaching the slabs to a bar which runs under both rails and out to the ends of the slab. This has the additional advantage of not being dependent on fastenings in wood ties to hold the crossing down. The first crossing of this type in the United States was installed in April 1972 on the Delray Connecting Railroad. It is the intention of the subcommittee to observe the performance of these crossings and report at intervals.

PREFABRICATED RUBBER CROSSINGS—PERFORMANCE OF CROSSINGS IN SERVICE OVER 10 YEARS

According to manufacturers' lists, there were 27 rubber highway crossings installed on common carrier railroads in 1961 or earlier. This committee was able to secure data in 1971 from maintaining railroads or by observation on 14 of these crossings.

Table 1

Location	*Railroad*	*Installation Date*	*Average Daily Traffic (R.R.*	*Highway)*	*Estimated Life Left (1971) Or Date Removed*	*Estimated Total Life*
New Britain, Conn.	PC	1955	4	Medium	4 Years	20 Years
Chicago, Ill.	Milw.	1956	20+	Heavy	Replaced 1971	15 Years
Ohio City, Ohio	EL	1957	24	2300	10 Years ±	24 Years
Petersburg, Mich.	PC	1958	1	14,000	Replaced 1964	6 Years
North Platte, Neb.	UP	1958	Very Light	Heavy*	Indefinite due to Traffic Change*	14 Years
Manchester, Conn.	PC	1958	2	Heavy	Indefinite	Indefinite
Phoenix, Ariz.	SP	1959	16	4500	10 Years	22 Years
Santa Fe Springs, Calif.	AT&SF	1959	22	35,000	25 Years	37 Years
Bryan, Ohio	PC	1960	1	Heavy	10 Years	21 Years
Peoria, Ariz.	AT&SF	1960	18	5800	35–40 Years	46–51 Years
New Brunswick, N. J.	PC	1961	1	Medium to Heavy	10 Years	20 Years
Lima, Ohio	PC	1961	30	3000	5 Years	15 Years
Markle, Ind.	EL	1961	26	2300	Indefinite	Indefinite
Emerado, N. D.	BN	1961	1	1700	Indefinite	Indefinite

* Majority of traffic was recently diverted from this road by new highway. Under previous heavy traffic would have required replacement.

While this sample is, of course, small, it was felt that it might shed some light on what kind of service life can be expected from these crossings. It should also be noted that some improvements in the design and manufacture of the crossings were made after the earliest installations. The 14 crossings are listed in Table 1 in chronological order of installation.

As shown in this table, the shortest service life was a crossing which required replacement after six years. Following this are three crossings which have actual or projected total service lives of 14 or 15 years. Seven, or 50%, of the crossings, have projected lives of 21 years or less. On the other hand, five, or about 36%, have lives estimated at greater than 35 years or indefinite.

Where maintenance costs were available (nine crossings), they ranged from no reported maintenance in 10 or more years to $185 per year (not including replacement).

The structure of the crossings consists of steel-reinforced rubber surface pads supported by wooden shims on top of the cross ties. The surface has shown superb wearing qualities under traffic (no data was available regarding the effect of studded tires in the last few years). However, the rubber is susceptible to damage by highway snow plows that can cut into the rubber with their blades. Because of the way the sides of the rubber pads contact the rail, water is normally prevented from getting down to the wooden shims and cross ties from the surface of the crossing. Keeping moisture out will greatly help in preserving the timber. Water, however, can enter from the ends of the crossing, especially if the track is on a grade or if, of course, the crossing actually becomes flooded. A gap between the roadway pavement and rubber crossing pad can also admit water. Once water is present, deterioration of cross ties and shims can begin the same as in a timber crossing. The water would not affect the slabs themselves, which could be reinstalled on new shims.

This report is submitted as information with a recommendation that the subject be continued.

Report on Assignment 3

Summary Reporting of Significant Publications on Grade Crossing Safety

H. L. Michael *(chairman, subcommittee)*, L. L. George *(vice chairman, subcommittee)*, J. P. Bolling, A. L. Carpenter, L. T. Cerny, C. A. Christensen, T. H. Kruttschnitt, R. V. Loftus, R. A. Mather, R. W. Mauer, D. G. Newnan, H. A. Richards, R. E. Skinner, C. W. Smith, J. L. Whitmeyer, H. J. Wilkins, H. L. Woltman, K. E. Wyckoff.

INTRODUCTION

Although the Subcommittee assignment wording is different this year than in other recent years, the activity of the Subcommittee has remained the same and is better reflected by the present wording. Each year significant published reports and developments related to railroad–highway grade crossing safety and which are located by the search mechanisms of the Subcommittee are reported in summary format. This year eight such developments or publications are reported.

MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

As forecast last year, this new Manual did become available in October 1971 and is currently available from the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 at $3.50 per copy [Order No. TD2.108:T672 (S/N 5001–0021)]. This important national standard for signing and marking all streets and highways in the United States should be quickly available for reference by every transportation engineer involved with highways in any way. Devices on highways at approaches to railroad grade crossings are included and some changes over previous standards are made.

The National Joint Committee (NJC) on Uniform Traffic Control Devices which was responsible for preparation of the new Manual was succeeded during 1972 by a new National Advisory Committee (NAC) on Uniform Traffic Control Devices. This new committee is advisory to the Federal Highway Administrator who has the responsibility for setting national standards in this area and will advise him on interpretations, research needs and changes required in the Manual. Plans for NAC operation are similar to those of the previous committee, and a large share of the membership of the NAC is to be selected from nominations made by the organizations which sponsored the NJC.

Official interpretations, approved experimentation with non-standard devices or with standard devices in non-standard uses, and changes in the Manual are being made continuously by the Federal Highway Administrator with advice of the NAC. These "Official Rulings on Requests for Interpretations, Changes, and Experimentations" are issued periodically in booklet form by the Federal Highway Administration and copies are available from the Office of Traffic Operations of that Administration. Volumes I (November 1971) and II (April 1972) together with an Errata booklet (January 1972) have been issued to date.

ENGINEERING ASPECTS OF RAIL–HIGHWAY GRADE CROSSING EVALUATION

A research report with the above title was published by the Texas Transportation Institute in August 1970 as Report 111-3F. The research reported was sponsored by the Texas Highway Department and the Federal Highway Administration.

The report describes an approach to the improvement of safety conditions at rail–highway grade crossings. It is based on comprehensive field studies conducted at selected grade crossing locations in Texas as a part of an overall study on grade crossing safety evaluation.

The diagnostic study team concept was used at 36 rail–highway grade crossing sites. The objective of the diagnostic study phase was to determine the type of protection that would provide acceptable efficiency under the conditions encountered on the various classifications of grade crossings. As a result of the investigations at the 36 crossings, recommendations were made for improving the safety conditions and included the development of new advance warning signs and sign location criteria. These signs were evaluated at nine crossing sites in a follow-up study. In addition, recommendations were made for implementation of engineering and environmental studies to improve safety at specific grade crossings.

Results of the team studies indicated that the diagnostic study team approach provides a highly reliable method for identifying, isolating and measuring factors which contribute to unsafe conditions at rail–highway grade crossings. Changes in existing protection, recommendations for improving and upgrading protective equipment, suggestions for on-the-spot safety measures which should be taken and the development of a line of communication between those responsible for safe operation of crossings were found to be benefits of the diagnostic team approach.

Recommendations of the study teams included many specific improvements and several general ones. Included in the latter were that all signs and devices giving advance warning or crossing control should be on both sides of the highway, that advance warning signs have a minimum size of 42 inches, that two advance warning signs are needed on each approach—one at a comfortable stop distance and the other at braking distance—that a warning to the motorist of poor visibility of approaching trains should be given where this factor occurs and that rough textured pavement should be placed near the first advance warning sign to help alert the driver.

THE VISIBILITY AND AUDIBILITY OF TRAINS APPROACHING RAIL–HIGHWAY GRADE CROSSINGS

The final report dated May 1971 with title as above by Systems Consultants Incorporated for the Federal Railroad Administration is available as Document PB202668 from the National Technical Information Service. The study investigated devices and color schemes, proposed or in use, on locomotives which serve to make the train visible or audible to motorists approaching grade crossings.

Conclusions from empirical testing of warning qualities of railroad horns in use on locomotives showed that they cannot warn motorists reliably when either the train or the motor vehicle is going very fast. To warn a motorist, the sound must penetrate his vehicle and override ambient noise to alert him while the vehicle is far enough away from the crossing to still be able to stop. It is not suggested that horns are seldom heard by motorists, but rather, that they fail to reach some motorists and are thus questionable as primary warning devices. In the encounter between a 50 mph train and a 50 mph motor vehicle, the typical horn could reach only about 50 percent of the drivers at the required 724 ft.

Improvements in horns are recommended, but it is noted that they do not change the finding that horns are not a suitable primary warning in high-speed encounters. These improvements include use of a high-output horn (the five-chime type is favored), mounting of horns high and up front and at each end for bidirectional locomotives, reduction of highway speeds at crossings where audible warnings are used as a primary warning, research on use of louder horns, development of varying-sound horns and re-evaluation of rules for the use of locomotive horns. It is also noted that there are crossings where the horn has little warning value but high nuisance value.

In the visibility portion of the research, many locomotives today were found to be hard to see by day or night. Color and lighting designs should have as their prime objective good conspicuity at 1000 ft at all angles throughout the great environmental and background diversity in which trains are operated. The following recommendations to achieve this objective are made:

1. Use a color scheme that contains two bright contrasting colors in a large area pattern.
2. Use two omni-directional xenon strobe lamps mounted on the cab roof near each side of the locomotive. They should provide high intensity in daylight and a lower intensity at night and should flash alternately when the train is moving and simultaneously at a lower rate when it is standing.

3. Use lighted panels for improving locomotive conspicuity at night. The suggested size is about 1 ft high and 6 ft long, fluorescent-lighted, and located above or below the cab windows on each side and on the nose of the locomotive.

TECHNOLOGICAL INNOVATION IN GRADE CROSSING PROTECTIVE SYSTEMS

This Technical Report dated June 1971 is a product of U.S. Department of Transportation's Transportation Systems Center at Cambridge, Mass. The report is available from the National Technical Information Service. The abstract of the report is as follows:

> "The constraints on innovative grade crossing protective systems are delineated and guidelines for development indicated. Inventory data has been arranged to permit an estimate of the classes of systems needed, the allowable costs, and contribution of various types of crossings to accidents. Many crossings warrant very limited expense and account for very few deaths. A number of approaches are possible for the intermediate cost classes, based on use of conventional signals with low-cost activation systems. Use of similar elements, singly or in combination, can also improve effectiveness of more expensive systems. The very high cost locations may well benefit from interconnection of train and vehicle detectors and small computers.
>
> "Extensive analysis and laboratory investigation has been carried out relating to a microwave telemetry alternative to conventional track circuits and possible crossing-located radar and impedance train detection systems."

INTERIM REPORT NO. 2, DIAGNOSTIC TEAM INSPECTIONS, EIGHT PROJECTS IN TEXAS

This report covers the findings of an inspection by a diagnostic team of eight rail–highway grade crossings where innovations of advanced theory and design for protection devices had been recommended and approved. Six of the eight projects had been completed prior to the inspection while one was partially complete and another incomplete.

The inspection was also used to refine the diagnostic process. The questionnaire used by team members to evaluate each crossing was shortened and clarified from that originally developed. Use of the questionnaire, however, produced the finding that it still requires improvement but that a good start had been made toward development of a prototype questionnaire which might be used throughout the nation.

Inspection of the eight improved crossings produced the finding that the elements of safety improvements were of such a nature that drastic improvements in reduced accident experience will be evident at each crossing. Conclusive results, however, must await further study, and it is recommended that the crossings be re-evaluated for at least an additional five years.

Crossing protection innovations included at the eight crossings consisted of new advance warning signs and advance warning signals. Other improvements, such as cantilevered signals, widened crossings and the addition of gates, were made at some of the crossings.

REPORT TO CONGRESS—RAILROAD–HIGHWAY SAFETY PART 1: A COMPREHENSIVE STATEMENT OF THE PROBLEM

This report prepared by the staffs of the Federal Railroad and Federal Highway Administrations was released in November 1971. Major topics covered include the history and trends of railroad–highway grade crossing safety, an evaluation of the current problem, improvement programs of the past and present, a review of the driver and his part in the problem, a similar review of train factors, a study of warning systems at crossings and an analysis of pedestrian protection. An appendix contains an excellent legal–historical review of the division of responsibility for the elimination and protection of railroad–highway grade crossings.

An economic analysis is employed in the report to provide an economic order of magnitude measure of the problem. The results indicate that if 15,000 crossings were provided with improved protection, accident costs would be reduced by nearly three times the installation and maintenance cost of the improvements. It appears from this analysis that 500 to 1000 crossings might economically warrant grade separation, primarily on the basis of reduced motor vehicle operating and delay costs.

The study recognizes that a major issue is that of financial responsibility and the history and trends of financing crossing protection is analyzed in depth. The total cost currently of railroad–highway intersection improvements is noted as being between $200 and $250 million annually, of which about $10 million are railroad expenditures. These improvements consist of the construction of over 400 grade separations and the installation of about 900 automatic protective devices annually.

Application of the systems approach to the problem is encouraged and it is noted that in urban areas, such an approach may find railroad relocation is the best solution.

The driver is credited with being an important contributor to grade crossing accidents, and the conclusion is stated that any effective program for improving safety at grade crossings should be oriented around the driver and his needs while approaching, traversing and leaving the crossing. The report recognizes that automatic devices which give the driver a uniform warning time prior to arrival of the train significantly simplify his task and substantially reduce motor vehicle–train collisions. On the other hand, it is found that more than three-fourths of the nation's grade crossings are protected with only static signs and that at least 70,000 or more crossings—with 500 or less vehicles per day and two or less trains per day—will probably not have justification for other than such protection. A need for more effective static signing is noted.

Improvements from new technology are noted as possible and include a wider range of warning system devices, more effective signs and a lower-cost active device. More reasonably priced devices to measure train speed and provide the driver with a uniform warning time are also stated as desirable. Modifications to the train in the form of improved visibility and audibility are also reviewed.

The report notes an annual casualty count of 1,350 persons involved in railroad right-of-way pedestrian accidents. In most cases, such pedestrians are considered trespassers by the railroads. Available preventive measures are noted as: fencing, more effective warning signs, separated pedestrian crossings, education and law enforcement.

In a final conclusion the report notes that there are "many facets and complexities to the grade crossing issue. The difficult questions of financial responsibility, divided jurisdiction, high cost of improvements, legal liability, and limited sources of funding have had a major impact on the ability to achieve new breakthroughs in solving the grade crossing problem. Safety has always been the major public issue. However, with the tremendous growth in motor vehicle miles, serious congestion on urban streets, and increasing interest in high-speed rail service as an alternative mode in transportation planning, improved highway and railway mobility has assumed new importance. Effective resolution of the grade crossing problem should consider both increased safety and more efficient use of the highway and railroad systems."

The second part of this two-part report to Congress was completed in July 1972 but a copy of the report was not made available to the Subcommittee in time to include its review in this report. Its content will be included in next year's report.

NEW RESEARCH PROJECTS

Two recently approved research projects in the area of grade crossing safety should produce valuable findings when completed. One of these is a study announced in July 1972 by the Department of Transportation to identify the relationship of certain railroad facilities to the urban environment and to propose methods for evaluating the economic, environmental and social consequences of their relocation. A contract for almost $200,000 was awarded to Stanford Research Institute for such a study over a period of 15 months. Field investigations will be conducted in five locations: Springfield, Ill.; Greenwood, S. C.; Wheeling, W. Va.; and two other locations. The objectives of the study are to determine the magnitude of problems in urban areas associated with the presence of railroad facilities, the type of rail facilities most susceptible to relocation and an acceptable manner of financing such projects.

The second research project of major interest is a pooled-fund research study of the effectiveness of new types of signs and markings at grade crossings and on their approaches as recommended by several recent research projects. A number of states are participating in the study which will include the installation of the new signs and markings at a substantial number and variety of crossings, an evaluation of their impact on approaching motorists and an estimate of their effectiveness in improving safety at grade crossings. This study is being sponsored by the Federal Highway Administration and the several cooperating state highway departments. Original plans called for a research agency to evaluate the effectiveness of the installed devices with the contract time to be about two years.

CONCLUSION

Much research and development in the grade crossing safety area are currently active and a number of significant publications in this area will undoubtedly appear in each of the next few years. As a consequence, it is recommended that the assignment of this subcommittee be continued as currently stated.

Report on Assignment 4

Evaluation of Developments in Passive and Non-Train-Actuated Grade Crossing Protection

T. H. Kruttschnitt *(chairman, subcommittee)*, H. J. Barnes, J. P. Bolling, W. A. Buckmaster, A. L. Carpenter, L. T. Cerny, C. A. Christensen, R. A. Downey, L. L. George, C. L. Holman, R. F. MacDonald, R. A. Mather, R. W. Mauer, H. L. Michael, H. A. Richards, R. F. Spars, J. L. Whitmeyer, H. J. Wilkins, K. E. Wyckoff.

Previous reports advised as to the increased interest in grade crossing protection by governmental bodies working with the railroads. From this interest the Federal Highway Administration issued to the state highway departments an Instructional Memorandum No. 21–1–68 providing for the study of rail–highway grade crossings, to recommend and install innovations of advanced theory and design for protection devices at grade crossings not necessarily restricted to current policy and criteria on the state and national level.

A Diagnostic Team was formed in Texas composed of one Federal Highway Administration engineer, three state highway engineers and six railroad engineers and signal personnel. Of the 14 projects approved for the State of Texas, there have been final reports submitted on ten; two have had interim reports made; and on four the work has not progressed to the point where reports can be made.

Four crossings were visited and reported on in May 1971, and since these were the first completed, much was learned. The reporting forms were revised and simplified so that a simple "yes" or "no" answer would suffice. This change was directed toward more ease in tabulation to arrive at a "team ratio" or "diagnostic ratio." Hopefully, the questionnaire can be refined to serve as a prototype which can be used by all responsible agencies to obtain a rating on grade crossing intersections. Properly implemented, this procedure, if aligned toward utilization by computers, can be a vehicle providing a tool for a better "hazard rating formula" that avoids the sterile results of the "academic formula."

The questionnaire, when properly applied, should be particularly useful in determining kind, size, type and number of passive signs to be used at a crossing to increase the vehicle drivers' awareness of the impending rail–street intersection.

An interesting fact was noted as a result of the questionnaires being completed by the Diagnostic Team. After the installation of the advance warning or passive signs, the team gave each crossing a higher and safer rating.

This fact gives strength to the idea that, when crossing signal protection is to be considered, passive signing should also be planned and installed in conjunction with the signal protection at the crossing. Further, a hazard index formula should be derived that takes these passive signs into consideration, as the results of the Diagnostic Team studies definitely show that the presence or absence of these advance warning signs has a direct bearing on the safety of the crossing.

The recent adoption of the Uniform Manual of Traffic Control Devices by the Federal Highway Administration has resulted in most of the states accepting this manual by their highway departments, either by statute or general acceptance. However, this uniform manual does not contain any passive signing in general relationship to railroads other than advance warning signs, standard pavement markings, and railroad crossbuck signs with the number-of-tracks sign. Also, uniform stop signs have been used by a number of railroads on certain crossings in conjunction with other standard regulatory passive signing.

The Diagnostic Teams in the various states are trying experimental signs as advance warning signs, and a black-bordered yellow reflectorized crossbuck sign with 4-ft blades and a 90° configuration has been manufactured and some installations have been made for evaluation purposes. From these will come recommendations from the state highway departments to the UMTCD Committee for inclusion in the next manual revision.

This committee will continue to be actively interested in this study and will report the progress made.

Report on Assignment 5

Study of Motor Vehicle Codes and Drivers' Licensing Practices

P. A. Shuster *(chairman, subcommittee)*, H. J. Barnes, J. M. Bates, J. P. Bolling, W. B. Calder, A. L. Carpenter, C. A. Christensen, W. J. Hedley, J. E. Spangler, R. F. Spars, J. R. Summers, H. J. Wilkins, H. L. Woltman, K. E. Wyckoff.

NEW DRIVERS' GUIDE ISSUED BY THE STATE OF MISSOURI

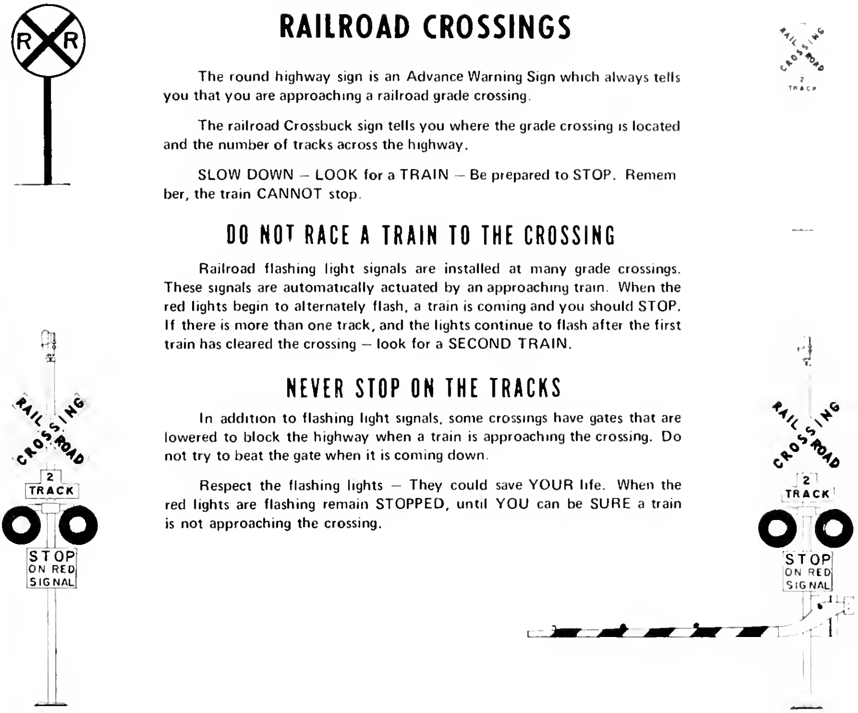
In May 1972, the State of Missouri issued a revised "Missouri Drivers' Guide," which has given the driver better information and instructions on how to meet the grade crossing situation. Fig. 1 shows the information as presented on pages 12 and 13 of the Guide. In addition to the illustrated material, the Guide also stipulates the following in another section:

> "Every motor vehicle transporting passengers for hire, every school bus, and every motor vehicle transporting corrosive, inflammable, explosive, or poisonous material, upon approaching any railroad grade crossing shall be brought to a full stop within 50 feet, but not less than 10 feet from the nearest rail of such railroad crossing."

We feel that the Missouri Drivers' Guide does an excellent job of presenting the railroad grade crossing situation to the new or potential driver. By devoting two full pages of the Guide to railroad crossing problems, sufficient emphasis has been placed in this area.

It should be noted that the "Stop on Red Signal" signs shown on the flashing light signal units in Fig. 1 are required by the State of Missouri, whereas most states do not require the use of these signs.

This report is submitted as information, with the recommendation that the subject be continued.



RAILROAD CROSSINGS

The round highway sign is an Advance Warning Sign which always tells you that you are approaching a railroad grade crossing.

The railroad Crossbuck sign tells you where the grade crossing is located and the number of tracks across the highway.

SLOW DOWN — LOOK for a TRAIN — Be prepared to STOP. Remember, the train CANNOT stop.

DO NOT RACE A TRAIN TO THE CROSSING

Railroad flashing light signals are installed at many grade crossings. These signals are automatically actuated by an approaching train. When the red lights begin to alternately flash, a train is coming and you should STOP. If there is more than one track, and the lights continue to flash after the first train has cleared the crossing — look for a SECOND TRAIN.

NEVER STOP ON THE TRACKS

In addition to flashing light signals, some crossings have gates that are lowered to block the highway when a train is approaching the crossing. Do not try to beat the gate when it is coming down.

Respect the flashing lights — They could save YOUR life. When the red lights are flashing remain STOPPED, until YOU can be SURE a train is not approaching the crossing.

Fig. 1—Items pertaining to railroad grade crossings from Missouri Drivers' Guide.

Report on Assignment 8

Investigate Uses and Types of Rumble Strips and Their Adaptability for Approaches to Highway–Railway Grade Crossings

R. E. Skinner *(chairman, subcommittee)*, W. A. Buckmaster, W. B. Calder, C. A. Christensen, R. A. Downey, L. L. George, C. I. Hartsell, J. C. Miller, R. H. Patterson, P. A. Shuster, J. R. Summers, J. M. Trissal, W. E. Webster, Jr., H. J. Wilkins, H. L. Woltman, C. H. Worboys, K. E. Wyckoff.

In the latter part of 1970, Ouchita Parish, Louisiana, in a cooperative effort with the Illinois Central Railroad (now Illinois Central Gulf Railroad), made some rumble strip installations on the approaches to the Well Road crossing of the IC. The crossing is located at Mile Post VD 76.5 on the Shreveport District at Watts, about three miles west of West Monroe, Louisiana.

The rumble strips consisted of individual pieces of plastic 4 inches wide, 12 inches long and ¾ inch thick with a curved top. The pieces were arranged in 8 rows across the traffic lane. The rows were 1 ft 3 inches apart for a total length of

10 ft. The rows consisted alternately of 5 and 6 pieces of plastic placed on 1-ft 7-inch centers with the joints staggered, with an overall width of about 9 ft.

The rumble areas on the south approach to the crossing were installed approximately 100 ft and 430 ft south of the track. Signs were installed on the right side of the road as follows: 440 ft south—a standard W 10–1 advance warning sign with an additional 18 x 24-inch sign mounted below it with the message "CROSS WITH CARE"; 210-ft south of track—a 24- x 18-inch sign with message "RUMBLE STRIP AHEAD"; 100 ft south—a diamond-shaped sign with message "DANGER RAILROAD CROSSING"; a standard 4-ft 90° crossbuck was located at the crossing. With the exception of the crossbuck, all signs had black letters on a yellow background.

The plastic pieces were glued to the existing asphalt pavement using a two-part epoxy glue. The plastic strips cost $1.00 each and the epoxy glue $5.25 per quart. The total material cost, including some extra strips, tax and freight was $502.37 which was assumed by the railroad. The Parish assumed the labor cost to install the strips, the entire cost of the signing and future maintenance.

An inspection in the latter part of May 1972 revealed that the plastic rumble strips on the north approach had been replaced with concrete rumble strips and that only about 25% of the individual plastic strips were still in place on the south approach. The Parish engineer stated that the asphalt paving softened in the summer time, destroying the bond between the strips and the pavement. He further stated they had replaced the missing strips until they ran out of extra strips and glue.

Two types of concrete rumble strips were installed on the north approach. Rumble Strip II installed approximately 400 ft from the center line of track had ¾-inch-deep corrugations on 3-inch centers. Rumble Strip III about 85 ft from the track was supposed to have 1¾-inch-deep corrugations on 4-inch centers; however, when poured, the concrete was too stiff and only about 25% of the strip area actually had this configuration. The signs were installed by the Parish approximately at the same location as on the south side of the crossing.

A general observation of the vehicle drivers' reactions to the rumble strips and signs was made over a period of a day and a half, with an actual count of each reaction made from 1:15 pm to 2:15 pm on one day. In the one-hour period 20 vehicles came to a complete stop at the crossing, 45 slowed down considerably and looked both ways down the track and 11 slowed down some. About half of the 11 that slowed down some would have had trouble stopping for an approaching train. The 45 that slowed down considerably could have stopped with no problems. With one exception, all vehicles reacted by slowing down, at least to some extent, as a result of these installations. During the entire one and one-half day observation, only three vehicles were observed driving on the opposite lane to avoid crossing the strips. With few exceptions the traffic is local in nature and consists of vehicles that use this route daily. The Parish engineer stated that prior to the signing and rumble strip installations very few vehicles even slowed down at the crossing. Up to this time he had received only one complaint, which was from some one he characterized as "one old lady" who was afraid of damage to her car. Public acceptance has been very good and many compliments have been made to the Parish. One aspect of the rumble strips that appeared to aid the effectiveness was the visibility of the strips themselves, as the whiteness of the plastic and concrete contrasted with the black asphalt pavement.

The 1969 ADT for Well Road was 210; however, the Parish engineer estimated that it is probably double that at present. There have been no accidents at the crossing either train-involved or non-train-involved since the rumble strips were installed. The vehicle speeds usually range from 35 to 45 mph. The normal rail traffic consists of four trains per day each way operating at a maximum speed of 45 mph.

As a result of the effectiveness of the Well Road installation, the Parish made a similar installation on Rowland Road which crosses the Missouri Pacific Railroad northeast of Monroe near the community of Sicard, Louisiana. The rumble strips were the same plastic as used on Well Road except that an additional strip was added in each line. The signing arrangement was as follows: Sta. 5+00—Standard W 10–1 advance warning signs both sides of road; Sta. 4+00—triangular "Yield Ahead" sign on left side and 2- x 2-ft "Warning Strip Ahead" sign on right side; Sta. 200—"Warning Strip Ahead" Sign on right side; Sta. 1+00 triangular "Yield" sign on right side. With the exception of the W 10–1 signs, all signs had green backgrounds with white letters. Visibility of these signs at night was good with the vehicles "high beam" lights. Vehicular reaction to this installation was good, but not as good as on Well Road.

The conclusions drawn from the observations made at these two crossings are as follows:

1. The rumble strip installations proved to be very effective in reducing vehicular speeds resulting in most drivers being more alert and having good control over their vehicles so that they could stop soon enough to avoid a train accident.
2. This same alertness and control would also reduce the possibility of rear-end collisions and other non-train-involved accidents.
3. The contrasting colors of the rumble strips and pavement were a definite factor in the effectiveness of the installations.
4. The use of highway type stop signs (mandatory stop) was not necessary for this treatment to be effective.

This is a progress report submitted as information. Your committee will continue to investigate and report on other uses of rumble strips.

Report on Assignment 9

Study of Public Pedestrian Crossings

J. L. Whitmeyer *(chairman, subcommittee)*, W. B. Calder, A. L. Carpenter, C. A. Christensen, J. W. Cruikshank, T. P. Cunningham, F. Daugherty, L. L. George, W. J. Hedley, J. A. Holmes, E. E. Howard, D. P. Insana, R. F. MacDonald, R. W. Mauer, J. C. Miller, J. E. Spangler, R. F. Spars, K. E. Wyckoff.

The Department of Transportation included a chapter on "Pedestrian protection along railroad rights-of-way" in its Part II report to Congress on August 16, 1972 on railroad–highway safety. Emphasis in this report was placed on the need to reduce pedestrian trespassing, particularly in urban areas, and recommendations were made that the railroads and local government agencies jointly review the situation and take practical steps to reduce trespassing.

The DOT recommendations are worth while, and it may be possible to reduce the trespassing situation by judicious use of fencing, erection of warning signs, restrictions in establishment of parking lots across the track from an industrial or commercial installation, safety education in schools and surveillance and enforcement of laws prohibiting trespassing.

Indications are that there are about 1350 pedestrian casualties annually on railroad right-of-way, as noted in the DOT report. Of these, an average of 126 train-involved pedestrian casualties—87 fatalities and 39 injuries—occur at grade crossings each year; 35 per cent of the pedestrian casualties, including those at grade crossing sites, are 20 years old and younger with over half the group under 14 years of age.

The general public, especially the young, do not have a full appreciation of the dangers present upon railroad rights-of-way and the only really effective measure is prohibition of access to the railroad right-of-way. In some situations this can be done by construction of fences, etc., as recommended in the DOT report.

Where pedestrian crossings are necessary, consideration should be given to construction of a grade separation versus construction of at-grade crossing, since the separation of grades eliminates the possibility of conflicts.

It is impractical to provide a complete physical barrier at a grade crossing to prevent access as a train approaches the crossing, and protective devices should be used to direct the pedestrian's attention to the danger. Signs, pass-through barricades, bells, signals or gates serve this purpose.

The California Public Utility Commission has adopted the use of a unique (passive) sign at pedestrian crossings. The sign measures 18 x 30 inches and the message, in black letters on white or reflectorized silver background, is as follows:

RAILROAD
RXR
CROSSING
PEDESTRIANS
ONLY

Automatic protection ordered by the California Public Utilities Commission can include the passive sign, a bell, and one or more pairs of flashing lights mounted on an 8-ft mast.

This is a progress report, submitted as information, with the recommendation the assignment be continued.

Report of Committee 11—Engineering Records and Property Accounting

C. R. Dolan, *Chairman*
R. D. Igou, *Vice Chairman*
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E. E. Strickland
J. B. Styles
T. A. Valacak
H. R. Williams

Committee

(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association

Your committee reports on the following subjects:

B. Revision of Manual.
No revisions to report.

2. Bibliography.
Progress report, submitted as information .... page 174

3. Office and Drafting Practices.
Report on the engineering and property accounting AFE file .... page 176

4. Special Studies.
Progress report on study of responsibility and functional reporting .. page 177

5. Application of Data Processing.
Brief status and progress report on three subjects .... page 178

6. Valuation and Depreciation.
Progress report, submitted as information .... page 179

7. Revision and Interpretation of ICC Accounting Classifications.
Progress report, submitted as information .... page 180

The Committee on Engineering Records and Property Accounting,
C. R. Dolan, *Chairman*

Report on Assignment 2

Bibliography

M. W. Bonnom *(chairman, subcommittee)*, P. J. Beyer, Jr., C. R. Dolan, L. D. Farrar, A. P. Hammond, L. W. Howard, R. D. Igou, J. L. Manthey, J. J. O'Hara, C. F. Olson, G. W. Smith, E. E. Strickland, T. A. Valacak, J. J. Weisbecker.

Your committee submits the following report of progress, presenting additional references with annotations.

Office Procedure

Reprographics, October 1971, pages 22–23. "Computer Graphics in Simulation and Electrical Applications."

How computer graphics augments engineering computer-aided design programs for subscribers of a mid-west time-sharing service center.

Modern Office Procedures, November 1971, pages 17–19. "Taking the Mystery Out of Calculators."

Manufacturers and users agree that the jargon of calculators needs clarification. The article provides a comprehensive glossary of calculator terms.

Modern Office Procedures, November 1971, page 20. "Putting Handles on EDP Jobs."

It is important to match job levels to the duties of each worker. The article provides definitions to give you a quick idea of job classifications so you can interview, evaluate, administer salaries and write job descriptions.

Reprographics, November 1971, pages 12–15. "Quality Drafting for Quality Microreproduction."

Meeting the retrieval requirements of microfilming has other benefits for those who use drawings: clarity, accuracy and conciseness.

Railway Age, April 10, 1972, page 38. "Microfilming EDP Output Cuts Costs for SCL."

The microfilm recorder works directly off computer magnetic tape and is able to record data at a higher rate of speed than the conventional impact printer. Savings in time and money are realized by printing time-saving, reduced mailing costs, reduction of storage costs, and reduced paper costs.

Reprographics, June 1972, pages 16–25. "Graphic Data Processing."

Visual Search Microfilm File (VSMF) uses non-silver diazo film. The film provides longer print life, insensitive to radioactive fallout, resists fungus attack and is less prone to scratching, marking and finger printing.

Railway Age, July 31, 1972, page 32. "CP Will Convert to Microtariffs; Shippers Like the New System."

Conversion of tariffs from paper to small microfilm sheets—or "microfiche"—each carrying 98 conventional pages, is now proceeding at Canadian Pacific headquarters in Montreal. When the process is in full use an estimated $100,000 savings to the CP alone will be realized.

Reprographics, July/August 1972, pages 26–29. "Efficiency of Centralized Drafting."

Optimum utilization of manpower and maximum saving in cost is best assured by overall department control. Cost reduction techniques can best be administered by the centralized organization.

Taxes

Federal Register, Vol. 36, No. 184, September 22, 1971. "Title 26—Internal Revenue—Amortization of Railroad Grading and Tunnel Bores."

Rules and regulations of amortization of railroad grading and tunnel bores—general rate, amount of deduction, special rule, election of amortization and definitions.

Valuation

The Appraisal Journal, January 1972, pages 144–149. "Building Costs and Trends."

Dodge Calculator National Building Cost Survey—Summary of six districts in the United States showing comparison of building costs and trends.

Engineering News–Record, March 23, 1972, pages 54–85. "EN-R Indexes of Costs Trends 1913–71—1st Quarter Report."

Latest trends in building cost indexes by city.

Materials prices.

Construction wage indexes.

The Appraisal Journal, April 1972, page 195. "Public Utility Valuation."

A discussion of the fair-value versus original-cost concepts of public utility valuation for rate-making purposes. Attention is focused on the acceptance or rejection of the fair-value and cost concept by the United States federal interstate and various state regulatory commissions and federal and state law courts.

Engineering News–Record, June 22, 1972, pages 64–96. "2nd Quarterly Cost Roundup—Contractors Gain More Control Over Costs."

The latest trends in building cost indexes.

Construction cost indexes.

Clients' Service Bulletin, August 1972, Vol. 49, No. 4. "Economic Penalties of Poor Property Records."

The effects of maintaining poor property records can be far-reaching—on the ad valorem tax bill, insurance premiums paid, Investment Tax Credit claimed, cash flow, maintenance and replacement costs, size of staff, perhaps even credit rating.

Accounting

The Journal of Accountancy, April 1972, pages 67–70. "Depreciation—A Reliability Gap."

The article calls attention to the reliability gap in accounting for depreciable assets. Explains the knowns of depreciation accounting and the dissatisfactions. Also the purpose of depreciation accounting.

Modern Railroads, June 1972, pages 52–54. "Can We Modernize Cost Accounting."

Proposed "functional" cost accounting system would tighten up rail operations, permit more competitive pricing. Cost accounting and statistical system would provide revenue and pricing decisions, profit center analysis, cost center analysis and operation decisions, scheduling and quality control of operations and service, investment planning and capital budgeting.

General

Railway Age, September 13, 1971, pages 29–34. "Can Railroads Live With the Federal Railroad Administration Track Standards."

$2.2 billion seen as the cost of meeting unmodified Federal regulations. The lack of funds, manpower, materials and time will force railroads to greatly reduce their competitiveness with other modes of transportation.

Railway Age, September 13, 1971, page 68. "Railroads Outline Their Approaches to Computer Security."

Attention is called to the importance of providing uninterruptible power supplies separate from commercial sources.

Several carriers responded to three questions asked by Railway Age: (1) How do you protect your data processing centers against physical damage to equipment and data? (2) How do you protect processed data against unauthorized use or theft? (3) Do you have a secondary data base in the event of damage to data and for processing facilities?

Modern Railroads, March 1972, pages 42–49. "Federal Track Standards: The Costly New Reality."

Engineers study impact of new law. Some regulations to become effective October 16, 1972.

Railway Age, March 6, 1972, pages 28–30. "Track Standards: FRA Tells the Railroads, 'Let's Talk'."

A railroad task force is now working up counter proposals—in the hope that a cards-on-the-table dialogue can keep the increasingly inflammatory issue from winding up in the courts.

Railway Age, May 29, 1972, page 52. "Videotape Training: Wave of the Future?"

The search for better methods of training the people responsible for keeping the railroads running is becoming more complex. The use of videotape, backed up by more conventional instructional material, might be the answer.

Report on Assignment 3

Office and Drafting Practices

W. C. Kanan *(chairman, subcommittee)*, P. J. Beyer, J. M. Bourne, R. H. Campbell, P. J. Hendricksen, J. J. Hoolahan, J. W. Kelly, J. G. Kirchen, J. L. Manthey, M. F. McCorcle, G. L. Muchow.

THE ENGINEERING AND PROPERTY ACCOUNTING AFE FILE

Your committee submits, as information, the results of answers to a questionnaire pertaining to the AFE file and its contents on completed AFE projects.

One of the most important investment property records of the railroad industry is the Authority for Expenditure file, or what is commonly referred to as the AFE file.

As a result of your committee's questionnaire, it was determined that in a majority of cases the AFE file on completed projects contains the following data:

1. A copy of the AFE or the original signed copy.
2. Field report data and "as built" prints.
3. Pertinent correspondence pertaining to the project.
4. The final statement of charges.
5. Retirement statements pertaining to the project.
6. The Roadway Completion Report.
7. Copy of any applicable agreement.

Upon completion of an AFE project, this file may be referred to many times for various reasons: (a) for original cost or ledger values in connection with retirements; (b) as supporting documentation in cases of litigation; (c) for ad valorum or Federal income tax information; (d) for billing or interest rental information in connection with joint facilities with railroads or others.

The detailed questions and answers are on file with the chairman of Committee 11.

As a matter of information, file retention regulations of the ICC require that AFE files and their related papers be retained in perpetuity unless specific permission is obtained from the ICC to destroy files pertaining to retired projects, i.e., line abandonments.

Report on Assignment 4

Special Studies

R. L. Ealy *(chairman, subcommittee)*, H. C. Boley, M. W. Bonnom, C. E. Bynane, J. R. Geary, P. R. Holmes, G. F. Ingraham, W. C. Kanan, W. H. Kiehl, F. J. Merscher, J. J. O'Hara, R. S. Shaw, Jr., E. E. Strickland, J. J. Weisbecker.

DEVELOPMENT AND USE OF RESPONSIBILITY AND FUNCTIONAL REPORTING AS RELATED TO MAINTENANCE OF WAY AND CAPITAL EXPENDITURES

Your committee submits the following progress report as information.

As a result of the submission of questionnaires to various railroads and the research of responsibility and functional reporting systems presently in use by several carriers, the subcommittee has drafted a report which is presently in the hands of the committee for review, comments or approval. It is expected that a final report on this assignment will be published next year.

The report on this subject will provide a suggested system which, with modifications to meet specific needs, can be utilized by any carrier so inclined to set up responsibility and functional reporting.

Following the submission of the final report on this subject, the data contained therein will be utilized by Subcommittee 5 in the application of data processing.

Report on Assignment 5

Application of Data Processing

L. F. Grabowski *(Co-chairman, Subcommittee on Accounting Phases)*, H. C. Boley *(Co-chairman, Subcommittee on Engineering Phases)*, R. H. Campbell, C. E. Bynane, P. L. Conway, Jr., C. R. Dolan, R. L. Ealy, W. V. Eller, A. P. Hammond, W. H. Kiehl, J. G. Kirchen, G. R. Gallagher, F. J. Merscher, J. B. Styles, H. R. Williams, H. C. Lippy.

MECHANIZATION OF DEPRECIATION DATA

The ICC conducted a Computerized Depreciation Analysis Conference on June 26, 1972, to acquaint interested carriers with the requirements and facets of computerized depreciation analysis that will form future requirements of the Commission. As the result of this meeting, formalized instructions for reporting of data to the ICC by the carriers are being developed. The new mechanized analysis methods are designed to produce a better product as well as to simplify the submission of data. Of particular interest, is the "one time" submission of the basic data, after which, upon request, only periodic update need be accomplished. Implementing the new system is still in its initial phase and data submissions have been restricted to a small number of carriers. The subject will be continued on the docket of Assignment 5.

MECHANIZATION OF PROPERTY RECORDS

The program to study and report suggested methods of producing average pricing for track retirements is being moved along as developments permit. The program continues to generate much interest, and more activity should result from the questionnaire being submitted to committee members. The questionnaire deals with methods for allocating recorded costs to reported units in track accounts; i.e., Accounts R&E 3, 8, 9, 10, 11 and 12 and associated Accounts R&E 1, 76 and 77.

DATA PROCESSING AND RESPONSIBILITY ACCOUNTING

The subcommittee is continuing its study of various roads' responsibility reporting systems for the primary purpose of developing ways to use such reporting for input data to Engineering Records and Property Accounting.

Report on Assignment 6

Valuation and Depreciation

C. E. Bynane *(chairman, subcommittee)*, P. L. Conway, Jr., W. V. Eller, G. R. Gallagher, L. F. Grabowski, M. J. Hebert, P. J. Hendricksen, E. H. Hofmann, P. R. Holmes, L. W. Howard, N. J. Hull, Jr., R. D. Igou, H. C. Lippy, J. G. Maher, D. C. Maris, P. G. McDermott, J. B. Styles, H. R. Williams.

(A) CURRENT DEVELOPMENTS IN CONNECTION WITH REGULATORY BODIES AND COURTS

ICC Bureau of Accounts

During fiscal year 1972 the Commission continued its five-year cyclical revue of equipment depreciation orders and the Accounting and Valuation Board issued 30 railroad depreciation orders. The Commission currently contemplates establishing the same cycle for analysis of rates applicable to road properties. Every effort will be made to avoid requesting carriers to submit studies for both road and equipment during the same fiscal year.

Sixty-five representatives of 35 carriers and the Association of American Railroads attended a meeting on Computerized Depreciation Analysis on June 26, 1972, in Hearing Room A, ICC Building, Washington, D. C. The meeting was opened with welcoming remarks by John A. Grady, director, Bureau of Accounts, followed by introductory remarks by Edward P. Johnson, chief, Section of Valuation and Depreciation, who then turned the program over to E. C. Hostettler, chief, Depreciation Branch, for an explanation of the program.

The overall purpose of the meeting was to provide an opportunity for carriers to gain understanding of new methods for estimating appropriate service life and salvage to be used for calculating revised rates of depreciation.

Mr. Hostettler's remarks on the general considerations of the computerized program, his discussion of the model form, analytical methods, rate implementation and depreciation reserve analysis have been summarized in a 14-page memorandum which has been distributed to all those in attendance at the meeting. For the benefit of those interested parties who were unable to attend, copies are available upon request to Mr. Hostettler.

On July 24, 1972, Director Grady of the Bureau of Accounts wrote Dr. Behling, vice president, Economics and Finance Department, Association of American Railroads, advising that the Bureau was considering an accounting change which would provide that the estimated cost of disposing of retired road property and equipment of a railroad be deducted from estimated salvage in computing service value to be depreciated over the useful life of the property. In other words, go from our present method of using gross salvage to the use of net salvage.

Dr. Behling circularized members of the General Accounting Committee for their comments and furnished each member of the General Committee with a copy of Mr. Grady's letter and an 11-page discussion of the pros and cons of the use of net vs. gross salvage. Interested members of AREA would be well advised to ask their chief accounting officers for a copy of the material.

Internal Revenue Service

On January 11, 1971, the President and the Treasury Department announced a "simplified and modern system of depreciation allowances," called the Asset Depreciation Range (or ADR) System, to be applied to machinery and equipment and other specified types of property. Proposed regulations were issued on March 12, and following public hearings on May 3–5, the final regulations were announced on June 22, and published in the Federal Register on June 23. Simultaneously with the publication of the regulations, Revenue Procedure 71–25 was published wherein the specifics for application of the new ADR System are to be found.

Report on Assignment 7

Revisions and Interpretations of ICC Accounting Classifications

J. G. Kirchen *(chairman, subcommittee)*, J. M. Bourne, P. L. Conway, Jr., J. R. Geary, N. J. Hull, Jr., G. F. Ingraham, J. W. Kelly, J. G. Maher, D. C. Maris, P. G. McDermott, J. McKeague, T. A. Valacak.

This is a progress report, presented as information.

Interstate Commerce Commission Order dated August 12, 1971 (Service date September 1, 1971) under Docket 32153 (Sub. No. 1) was issued, amending the Uniform System of Accounts for Railroad Companies, requiring the carriers to maintain a separate file of records sufficient to support certain transactions with affiliated companies, by adding General Instruction 1–10, Transactions with Affiliated Companies to Part 1201 of the Code of Federal Regulations, effective January 1, 1971.

Proposals

The Interstate Commerce Commission has issued the following Notice of Proposed Rulemaking and Order (49 CFR Part 1201) on May 17, 1972 (Service date May 30, 1972) under Docket No. 32153 (Sub. No. 2) requesting from the carriers their views regarding the proper timing for the Accounting for Retirement of or Recognition of, Impairments in Value of Track Structures. (Time for filing statements of facts, views and arguments extended to December 31, 1972).

The Bureau of Accounts has issued the following proposals pertaining to Accounting Series Circular No. 130 on June 15, 1972.

Item I—Proposed Modification of Case 122 interprets the expression "general standard" as set forth in Instruction 1–2 (d) to mean a "guide line" rather than a set rule that must be met in each instance when considering an item for exclusion from Ordinary Income and inclusion in Account 570, Extraordinary Items (Net) or 580, Prior Period Items (Net). This Proposed Modification also includes six factors [(a) through (f)] that should be considered in determining whether use of Accounts 570 or 580 should be requested on the basis of materiality.

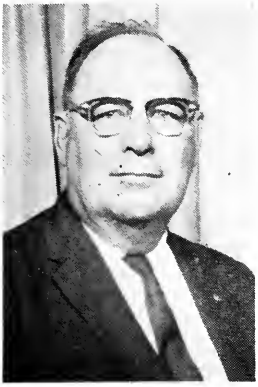
Item II—Two Proposed New Cases:

The first new case states that it is *not* proper to record the value of reusable salvage in inventory at an amount exceeding the recorded cost (ledger value) of the property removed.

The second new case states that it is *not* proper to capitalize materials withdrawn from inventory and used in a capital project (construction, betterment, rebuilding, etc.) at an amount exceeding the inventory carrying value.

The Interstate Commerce Commission has issued the following Notice of Proposed Rulemaking and Order (49 CFR Part 1201) on August 1, 1972 (Service date August 9, 1972) under Docket 32153 (Sub. No. 4) requesting from the carriers their views regarding the increasing of the minimum rule for property acquisitions, additions and betterments established in Instruction 2–2, from $500 to $1500.

Report of Committee 13—Environmental Engineering



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L. R. TIERNEY
E. M. WALTERS*
J. W. WEBB, JR.
J. M. WETZEL
J. W. ZWICK

Committee

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* Died July 3, 1972.
(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.
No report.

1. Water Pollution Control.
Progress report, presented as information .... page 185

2. Air Pollution Control.
Progress report, presented as information .... page 189

3. Land Pollution Control.
Progress report, presented as information .... page 193

4. Industrial Hygiene.
Manual recommendations submitted for adoption are printed in Part I of this Bulletin.

5. Plant Utilities—Design, Construction and Operation.
Progress report, presented as information .... page 197

6. Corrosion Control.
   Progress report, presented as information .... page 201

7. Noise Pollution Control.
   Tentative Manual recommendations, presented as information ...... page 203

THE COMMITTEE ON ENVIRONMENTAL ENGINEERING,
C. F. MUELDER, *Chairman.*

Earl Maurice Walters
1915-1972

Earl Maurice Walters of 1511 East 3rd Street, St. Paul, Minnesota, (55106), assistant engineer of environmental control, Burlington Northern Inc., died on July 3, 1972, after a very short illness. He is survived by his wife, Dolores, and two daughters, Holly and Casey, who are living with Mrs. Walters.

"Maury," as he was affectionately known by his friends, was born in Manhattan, Montana, on April 17, 1915, and spent his early years around this area of Montana until he went to Montana State College at Bozeman, where he received a B.S. degree in chemical engineering on June 4, 1936. He continued his education by earning a M.S. degree in metallurgical engineering at the University of Idaho at Moscow, Idaho, on May 31, 1937.

The day after receiving his Masters degree, he went to work for the former Northern Pacific Railway as a water inspector at Glendive, Montana. On February 16, 1942, he entered the Army as a First Lieutenant in the Corps of Engineers and saw service in the American and Pacific Theaters of War. He was discharged on March 26, 1946, as a major and returned to the Northern Pacific on April 1, 1946. On May 1, 1957, he was promoted to assistant engineer water service and power plants, and with the merger of the Northern Pacific into Burlington Northern Inc., he became assistant engineer of environmental control.

He became an active member of the American Railway Engineering Association in 1957, and a member of Committee 13 in 1958, serving admirably on various subcommittees, being also the collaborating member for Committee 13 with Committee 1—Roadway and Ballast.

All AREA members who were fortunate enough to have worked with him, will miss the help that he was always eager and ready to give. In addition to those who did not have the good fortune to work with him, there are those of his church, societies and fellow railroaders who will sorely miss his help and companionship.

Report on Assignment 1

Water Pollution Control

J. L. Goss *(chairman, subcommittee)*, C. A. Obma *(vice chairman, subcommittee)*, D. J. Inman, F. L. Manganaro, J. C. Neal, G. H. Nick, N. E. Smith, R. J. Thompson

Under this assignment your committee presents, first, a report on state requirements for certification of water plant operators, followed by a directory of water pollution control agencies (see page 186).

STATE CERTIFICATION REQUIREMENTS FOR WATER PLANT OPERATORS

Your committee submits the following general statement on state requirements for certification of water plant operators. This will be the only report on this subject and is submitted for information only.

Most states require certification of treatment plant operators with a few states operating on a voluntary basis. From the trend during the past five years, it can be assumed that all states in the near future will require mandatory certification of all personnel operating water supply or waste water treatment plants.

State certification of water supply or waste water treatment plant operators has, in general, one common goal: to employ technically competent, alert and responsible people in charge of operating facilities serving the public. Certification is not usually designed as a rating system for upgrading operators but is normally a part of the position requirement to provide for adequate staffing.

Most states use the following definitions relating to certification requirements:

> "Public Water Treatment Plant" means that portion of a public, private or corporate water system which in any way alters the physical, chemical or bacteriological characteristics of potable water furnished to the public for human consumption.
>
> "Waste Water Treatment Plant" means the facilities provided for the collection, treatment and disposal of sewage or industrial wastes.
>
> "Operator" is the person who has responsibility for the operation of a water treatment plant, waste water treatment plant, or any of the functional divisions of such systems.
>
> "Board or Commission" shall mean the Board of Examiners or the regulatory body under which the certification program is administered.
>
> "Certificate" shall mean a certificate of competency issued by the Commission or Board stating that the applicant has met the requirements for the specified operator classification. Certificates are normally renewed annually.

All states classify water and waste water treatment plants. The criteria for classifying public water treating plants vary widely from state to state. In some states design flow or population served is used as a basis. Other states use pollutional loading as the classification index. A large number of states use various systems of rating values based on size and type of plant, character of treatment, source of supply or potential health hazards. Classification of waste water treatment plants is usually based on some combination of size, types of work, character and volume of waste to be treated, pollution index, degree of plant operation control required and the use and nature of water resources receiving the plant effluent.

Certification programs generally provide multiple levels or grades of operator licenses. The grade of operator is in most cases intended to parallel the plant classification. Rules and regulations usually specify it is unlawful for any person, municipal corporation or other corporations to operate a public water treating plant or waste water treatment plant unless the operator holds a valid certificate of registration issued by the Board or Commission in a grade corresponding to the class of plant under his operation.

Persons who desire to become a state certified water or waste water treatment plant operator must make application on the proper form and in most cases submit to an examination. Such examinations may consist of a written, oral or any other type or combination of types of examination desired by the Board or Commission to determine if the applicant is qualified.

Applicants for a treatment plant operator's certificate are usually required to meet certain educational and experience requirements for the grade of certificate applied for, with experience qualifications being in the same field as the type of certificate for which the applicant is applying. Qualification requirements again vary widely from state to state. A few states are specific in educational and experience requirements for each grade of operator, such as a college degree and so many years of experience for the top grade and less demanding criteria for lower grades. Most states use a combination where years of experience can be substituted for years of education and vice versa. In some states requirements for the lower grade merely require that the applicant demonstrate an aptitude for operation of the facility for which the individual will be certified. A few states spell out in detail the qualification requirements for each certificate grade. These specifics outline nature of work, examples of work, essential knowledges required, abilities and skills required, desirable experience and training, and qualifications for each grade. Applicants shall in most cases be further required to give evidence of possessing no physical disability which would impair their ability to operate a plant, give evidence of good moral character, dependability, initiative, interest in work and other pertinent characteristics as required by the board or commission.

Railways operating public water treatment plants or waste water treatment plants should consult the certification Board in the various states in which they operate to determine the specific requirements and qualifications to obtain the required state certificates for their plant operators. In practically all cases, those seeking certification must be local persons who have direct supervision or direct responsibility for operation of the plant.

1.4 DIRECTORY OF WATER POLLUTION CONTROL AGENCIES

1.4.1 What is considered by governmental authorities to be a pollutant? Are there any specific amounts, guidelines or parameters which can be used to determine what quantities or concentrations constitute pollution? One must know the answers to these questions in order to alleviate a pollution complaint.

1.4.2 Local and state governmental agencies are issuing regulations providing this information. State governmental help is available from the following control agencies:

Water Improvement Commission
State Office Building
Montgomery, Alabama 36104

Alaska Department of Health and Welfare
Alaska Office Building
Juneau, Alaska 99801

Division of Environmental Health
State Department of Health
4019 N. 33rd Street
Phoenix, Arizona 85017

Arkansas Pollution Control Commission
1100 Harrington Avenue
Little Rock, Arkansas 72201

Division of Water Quality Control
State Water Resources Control Board
1416 9th Street
Sacramento, California 95814

Department of Public Health
4210 East 11th Avenue
Denver, Colorado 80220

Division of Water Pollution Control
Water Resources Commission
State Office Building
Government Center
100 Cambridge Street
Boston, Massachusetts 02202

Engineering & Sanitation Division
State Department of Health
P. O. Box 640
Boise, Idaho 83702

State Water Resources Commission
Room 223
State Office Building
650 Main Street
Hartford, Connecticut 06115

Delaware Air and Water Resources Commission
Loockerman Street & Legislative Avenue
Dover, Delaware 19901

District of Columbia Department of Public Health
300 Indiana Avenue
Washington, D. C. 20001

Air & Water Pollution Control Commission
306 W. Jefferson
Tallahassee, Florida 32201

State Water Quality Board
47 Trinity Avenue S.W.
Atlanta, Georgia 30334

Public Health & Social Services
Territory of Guam
P. O. Box 128
Agana, Guam 96910

Environmental Health Division
Hawaii Department of Health
P. O. Box 3378
Honolulu, Hawaii 96801

Water Resources Commission
Station B
200 Mill Street
Lansing, Michigan 48913

State Sanitary Water Board
State Office Building
400 South Spring Street
Springfield, Illinois 62706

Stream Pollution Control Board
1330 West Michigan Street
Indianapolis, Indiana 46206

Water Pollution Division
State Department of Health
State Office Building
Des Moines, Iowa 50319

Environmental Health Services
State Department of Health
Topeka Avenue at Tenth
Topeka, Kansas 66612

Kentucky Water Pollution Control Commission
275 E. Main Street
Frankfort, Kentucky 40601

Louisiana Stream Control Commission
P. O. Drawer FC
University Station
Baton Rouge, Louisiana 70803

Water & Air Environmental Improvement Commission
State House
Augusta, Maine 04330

Bureau of Environmetal Hygiene
State Department of Health
2305 N. Charles Street
Baltimore, Maryland 21218

Water & Liquid Waste Division
Department of Health & Social Service
P. O. Box 2348
Santa Fe, New Mexico 85701

Pure Waters Authority
248 State Street
Albany, New York 12208

State Department of Water & Air Resources
P. O. Box 9392
Raleigh, North Carolina 27603

Minnesota Pollution Control Agency
459 Board of Health Building
University Campus
Minneapolis, Minnesota 55440

Mississippi Air and Water Pollution Control Commission
P. O. Box 827
Jackson, Mississippi 39205

Missouri Water Pollution Board
P. O. Box 154
Jefferson City, Missouri 65101

Montana Water Pollution Council
State Board of Health
Laboratory Building
Helena, Montana 59601

Nebraska Water Pollution Control Council
Box 94757
State House Station
Lincoln, Nebraska 68509

Bureau of Environmental Health
State Department of Health and Welfare
970 Sutro Street
Reno, Nevada 89502

Water Supply & Pollution Control Commission
61 South Spring Street
Concord, New Hampshire 03301

Division of Air & Clean Water
State Department of Health
P. O. Box 1540
Trenton, New Jersey 08625

Division of Sanitary Engineering
State Department of Health
Pierre, South Dakota 57501

Tennessee Stream Pollution Control Board
Cordell Hull Building
Sixth Avenue, North
Nashville, Tennessee 37219

Environmental Health & Engineering Services
State Department of Health
Bismarck, North Dakota 58501

Water Pollution Control Board
State Department of Health
P. O. Box 118
Columbus, Ohio 43216

Environmental Health Service
State Department of Health
3400 N. Eastern
Oklahoma City, Oklahoma 73105

Oregon State Authority
P. O. Box 231
Portland, Oregon 97207

Division of Sanitary Engineering
State Department of Health
P. O. Box 90
Harrisburg, Pennsylvania 17120

Puerto Rico Department of Health
Ponce de Leon Avenue
San Juan, Puerto Rico 00908

Division of Water Pollution Control
Rhode Island Department of Health
335 State Office Building
Providence, Rhode Island 02903

South Carolina Water Pollution Control Authority
J. Marion Sims Building
Columbia, South Carolina 29201

Division of Environmental Sanitation
Dept. of Public Health
State Office Building
Cheyenne, Wyoming 82001

Texas Water Quality Board
1101 Lavaca Street
Austin, Texas 78701

State Water Pollution Control Board
44 South Medical Drive
Salt Lake City, Utah 84113

Vermont Department of Water Resources
State Office Building
Montpelier, Vermont 05602

Virgin Islands Department of Health
Charlotte Amalie
St. Thomas, Virgin Islands 00802

State Water Control Board
4010 West Broad Street
P. O. Box 11143
Richmond, Virginia 23230

Washington Water Pollution Control Board Commission
P. O. Box 829
Olympia, Washington 98501

Division of Water Resources
Department of Natural Resources
1201 Greenbrier Street, East
Charleston, West Virginia 25311

Air & Water Resources Management
Division of Resources Development
1 West Wilson Street
Madison, Wisconsin 53702

Report on Assignment 2

Air Pollution Control

A. F. Butcosk *(chairman, subcommittee)*, R. C. Archambeault, W. F. Arksey, A. J. Dolby, J. H. Flett, C. E. Peterson, R. J. Spence, E. M. Walters.

Your committee presents as information a current Directory of Government Enforcement Agencies in the United States and Canada, followed by an additional reference for control of particulate emission during the operation of incinerators.

2.2 DIRECTORY OF GOVERNMENTAL ENFORCEMENT AGENCIES

2.2.1 Assistance and information concerning governmental regulations pertaining to air pollution may be secured from the following:

State of Alabama Department of Public Health
State Office Building
Montgomery, Alabama 36104
Telephone: 205–269–7634

Department of Environmental Conservation
Pouch O
Juneau, Alaska 99801
Telephone: 907–586–6721

Division of Air Pollution Control
4019 N. 33rd Avenue
Phoenix, Arizona 85017
Telephone: 602–271–5306

Arkansas Department of Pollution Control in Ecology
1100 Harrington Avenue
Little Rock, Arkansas 72202
Telephone: 501–371–1701

Air Resources Board
1025 "P" Street
Sacramento, California 95814
Telephone: 916–445–1511

Air Pollution Control Division
Colorado Department of Health
4210 E. 11th Avenue
Denver, Colorado 80220
Telephone: 303–388–6111

Air Pollution Control Section Dept. of Environmental Protection
79 Elm Street
Hartford, Conn. 06115
Telephone: 203–566–4030

Delaware Dept. of Natural Resources & Environmental Control
Division of Environmental Control
Tatnall Building, Capitol Complex
Dover, Delaware 19901
Telephone: 302–678–4761

Air Pollution Division
Dept. of Human Resources
25 "K" Street, N.E.
Washington, D. C. 20002
Telephone: 202–629–3748

Department of Pollution Control
Suite 300, Tallahassee Bank Bldg.
315 S. Calhoun Street
Tallahassee, Florida 32304
Telephone: 904–224–9151

Air Quality Control Branch
Georgia Dept. of Public Health
116 Mitchell Street, S.W.
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Indiana State Board of Health
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Kansas State Department of Health
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Kentucky Air Pollution Control Commission
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Air Control Section
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New Orleans, Louisiana 70160
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Department of Environmental Protection
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Bureau of Air Quality Control
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Bureau of Air Use Management
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Division of Air Pollution Control
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Mississippi Air & Water Pollution
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Missouri Air Conservation Commission
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Montana State Department of Health
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Division of Air Pollution Control
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New Jersey State Bureau of Air
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Environmental Improvement Agency
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Bureau of Air Quality & Noise Control
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Salt Lake City, Utah 84113
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Division of Environmental Health
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Washington State Department of Ecology
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West Virginia Air Pollution Control Commission
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Bureau of Air Pollution Control & Solid Waste Disposal
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Industrial Hygiene Services
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2.3.7 Operation of Incinerators

(f) Additional details of operating procedures are cited in a Federal Publication, as listed in Reference 2.

REFERENCES

(1) Air Pollution Engineering Manual 999-AP-40, U. S. Department of HEW, PHS, Bureau of Disease Prevention Environmental Control, National Center for Air Pollution Control, Cincinnati, Ohio, pp 413–445.

(2) Interim Guide of Good Practice For Incineration at Federal Facilities, U. S. Department of HEW, PHS, Consumer Protection and Environmental Health Service, National Air Pollution Control Administration, Raleigh, North Carolina, Nov. 1969, pp 11–1 to 11–5.

Report on Assignment 3

Land Pollution Control

E. S. JOHNSON *(chairman, subcommittee)*, R. C. BROWNLEE, L. R. BURDGE, P. P. DUNAVANT, T. L. HENDRIX, JR., E. T. MYERS, J. M. WETZEL, J. W. ZWICK.

Your committee submits as information the following report pertaining to the disposal of toxic wastes and invites comments thereon.

3.4 DISPOSAL OF TOXIC WASTES

3.4.1 General Statement

(a) The disposal of toxic wastes has become one of the most difficult problems facing those charged with the environmental affairs of railroad operations. The atmosphere and oceans can no longer be considered as ultimate sinks for harmful or deadly wastes. Indiscriminate burning or dumping of waste material is no longer possible, and public disposal facilities are becoming increasingly selective as to the materials which they will accept.

(b) The responsibility for safe disposal of toxic wastes lies with the individual generating the wastes. It is therefore necessary that those involved, directly or in a supervisory capacity, with waste producing and waste disposal operations be generally familiar with common toxic materials and their proper handling.

(c) Experience in the treatment of toxic wastes has led to the concept of toxicity thresholds. This concept assumes that below certain concentrations all materials are nontoxic. The concentration at which a certain material becomes toxic for a certain organism is the toxicity threshold of that material for that organism. Therefore, when speaking of toxic materials one must consider both the concentration of the material and the nature of the host organism. The toxicity of a material to an organism is measured by the median tolerance limit (TL_m or TL_{50}) TL_{50} is the concentration of a substance in laboratory water at which 50 per cent of the test organisms survive over a specified period of exposure. The exposure time is generally 24, 48, or 96 hours. The effects of toxic materials on the host organism may not be immediately obvious and may vary from instant death to interference with reproduction processes.

3.4.2 Toxic Wastes

3.4.2.1 General

(a) A toxic material becomes a toxic waste at such time as the material is discarded, spilled, contaminated or otherwise rendered unusable for the purpose it was originally intended. The sources of toxic wastes encountered by the railroad industry can generally be categorized as (1) normal plant operations and (2) in-transit spills and leaks. Toxic wastes produced in the course of normal operations can be inventoried, studied, and treated in accordance with sound engineering practice. Toxic wastes produced by in-transit spills almost always create emergency situations which afford very little time for development of safe and effective disposal procedures.

3.4.2.2 Common Toxic Wastes

(a) Toxic wastes commonly generated in the course of normal railroad operations include the following: chromates, borates and certain other additives used in locomotive cooling systems; phenols, creosote and Bolidensalt from wood preserving plants; oils and fuel oils, solvents and industrial cleaners; tannic acid and certain other boiler water additives; wastes from water treating plants; residual amounts of herbicides and pesticides used on company property; and effluent from car and locomotive washing operations.

(b) The above materials are generally not amenable to conventional sewage treatment processes. In fact, they are usually detrimental to the treatment plants. Municipalities are imposing strict regulations on the discharge of toxic materials into sanitary sewers and are monitoring industrial discharge points to assure that the regulations are met. It is becoming increasingly incumbent upon industry to segregate and treat, or otherwise dispose of, its own toxic wastes.

3.4.2.3 In-Transit Spills

(a) Toxic wastes produced from in-transit spills and leaks are usually the result of derailments, rough handling, and/or defective rolling stock. Millions of tons of potentially hazardous materials are transported annually by rail without incident; however, it must be recognized that there are circumstances under which any of the materials hauled could conceivably be involved in an in-transit spill. The unpredictable and serious nature of in-transit spills of toxic materials demands that a plan of operation be developed to handle these emergency situations. The immediate safety of employees and the general public is the most important factor to be considered in the event of an in-transit spill. The intent of this chapter, however, is to consider the safe and effective disposal of such spills.

(b) Reporting the incident to authorities and company officials is the first phase in handling in-transit spills. The railroad should designate several knowledgeable officials to be notified and make their names and phone numbers available to operating personnel. If the spilled material presents an immediate hazard, the Chemical Transportation Center (Chemtrec) should be contacted at 800–424–9300 for procedural instructions. The Environmental Protection Agency, and Coast Guard if the spill endangers navigable waters, must be notified immediately, as should local fire, law enforcement and health agencies and the state and local pollution control agencies. The manufacturer–shipper should be contacted immediately.

(c) Information on the spilled material must quickly be assimilated. Damaged car numbers must be traced if the identity of the material is not apparent. The manufacturer's medical consultant can give instructions for first aid and safety precautions and their engineering department will know the best procedures for pollution abatement. Cooperative efforts of the shipper, the carrier, and the pollution control agencies must be quickly coordinated to minimize pollution problems.

(d) The success of pollution abatement action in the event of an in-transit spill is nearly always dependent upon how soon the abatement action takes place after the spill occurs. The material should, if possible, be isolated and contained. If the material reaches a water course, downstream municipalities and industries must be alerted so they can determine whether to shut down their raw water intakes. Adjacent landowners must be advised of any potential hazard to crops and livestock.

(e) Follow-up procedures are often necessary to assure that a potential pollution source does not remain after the spill has been cleaned up. In most cases this will involve only periodic inspections of the site. In the event of a particularly dangerous spill, it may be necessary to subsequently sample wells and drainage systems in the area to establish that the material has not infiltrated these facilities.

3.4.3 Treatment and Disposal Methods

3.4.3.1 General

(a) The first step in the treatment and disposal of toxic wastes is identification and location of the sources of the wastes. Materials such as chromates, zeolite wastes, and lye vat residue which are generally discharged in slug loads will completely upset biological treatment plants. Obviously, these and other toxic materials must be given special consideration in waste treatment design. Materials which are toxic in small concentrations must be isolated from the waste water and storm drains and from the conventional solid waste disposal facilities. Safe and dependable collection and handling procedures must be established for these wastes and an inventory system set up to assure that all of the wastes reach ultimate disposal.

3.4.3.2 Biological Treatment

(a) Biological waste treatment methods are not generally amenable to treating toxic wastes. Phenols have been successfully treated in aerobic lagoons and small concentrations of cyanide have been treated by aerobic biological processes. Biological treatment of toxic wastes is very delicate and requires long periods of acclimation to establish cultures which can stabilize these wastes. The systems are susceptible to shock loads and operational changes.

3.4.3.3 Chemical-Physical Treatment

(a) Precipitation and/or flocculation followed by clarification has been used with considerable success in treating waste waters from railway shops and fueling facilities. Hexavalent chromium, for instance, may be precipitated in the trivalent form by the addition of ferrous iron to the same system used to flocculate oil emulsions. Other heavy metals can be similarly precipitated. It should be noted that heavy metals are monitored in the elemental form. Reducing hexavalent chromium to the less objectionable trivalent form, for instance, will generally not meet water quality regulations. The metal itself must be removed. The toxic effects of many pesticides can be chemically reduced, as can those of strongly acidic or alkaline solutions.

(b) Chemical–physical processes often solve a water pollution problem by creating a potential land pollution problem. Solid waste, in the form of dried sludge and floc, may contain toxic or potentially toxic compounds and must be handled accordingly.

3.4.3.4 Recycling and Beneficial Uses

(a) The optimum solution to the toxic waste disposal problem is to recycle or develop an alternate beneficial use for the material. Engine coolants can be salvaged and recycled with the installation of collecting tanks and filtering systems at terminal points. Salvaged fuel oil can be used as boiler fuel in some instances. Salvaged oil can be applied to yard and maintenance roads in some areas; however, appropriate pollution control agencies should be consulted before this disposal method is undertaken.

3.4.3.5 On-Site Disposal

(a) On-site disposal of toxic wastes must be carefully planned and supervised. Every precaution has to be taken to assure that the toxic materials will remain at the disposal site and not enter the environment through the action of winds, surface runoff, or groundwater. On-site disposal must not be practiced if there are dangers to the public or wildlife.

(b) Impoundment and evaporation is an effective on-site disposal method for small amounts of liquid wastes in areas having favorable climatological conditions. Organic sludges can be spread in unused areas and turned under with a plow. The waste is subsequently broken down and assimilated by soil bacteria. This method is often effective for lye vat residue if discretion is used in the amount applied and the locality chosen for disposal.

(c) Deep well disposal is falling into increasing disfavor among pollution control agencies. The Environmental Protection Agency rarely allows deep well disposal of toxic wastes.

(d) Incineration is becoming popular as an on-site disposal method for liquid, solid and gas wastes. Care must be exercised, as many combustible wastes produce harmful by-products. Chlorinated hydrocarbons used in many degreasers and other solvents form hydrochloric acid and possibly phosgene upon combustion. Competent consultants should be retained to aid in the selection of incinerators.

REFERENCES

1. Eckenfelder, W. W., Jr., *Industrial Water Pollution Control.* McGraw–Hill, Inc., New York, New York, 1966.

2. Garrett, Jack T., "The Anatomy of an In-Transit Spill," Journal of the Water Pollution Control Federation, Vol. No. 43, pp 773–778, May 1971.
3. Sawyer, Clair N.; McCarty, Perry L., *Chemistry for Sanitary Engineers.* McGraw-Hill, Inc., New York, 1967

Report on Assignment 5

Plant Utilities—Design, Construction and Operation

J. L. Engler *(chairman, subcommittee),* R. G. Bielenberg, L. R. Burdge, J. W. Gwyn, F. O. Klemstine, P. M. Miller.

Your committee submits as information the following report pertaining to high-speed fueling and fueling station filtration and invites comments and criticisms thereon.

5.8 DIESEL LOCOMOTIVE HIGH-SPEED FUELING

5.8.1 General Considerations

(a) With increased scheduling of trains, quick turns at division points, and increasing distances between fueling stations it is becoming more important to reduce time allotted to refueling locomotives. High-speed fueling should be a one spot service facility providing absolutely dependable automatic fueling for run-through servicing of locomotives ready for dispatch.

(b) Design of new modern locomotive high-speed fueling facilities should be planned for heavy-duty operation with adequate space between tracks for handling equipment and free movement of personnel.

(c) The following information published in Chapter 13 of the AREA Manual is applicable to high-speed fueling operations and should be referred to:

5.6.1 Diesel Fueling Facilities
5.6.2 Fuel Oil Storage Facilities
5.6.4 Fuel Oil Distribution Lines
5.6.5 Unloading Facilities
5.6.7 Use of Economy Grade Fuel Oils

5.8.2 Fuel Oil Pumping Facilities

5.8.2.1 Selection of Pump

(a) Types. Electric-driven pumps of either turbine, centrifugal, rotary or gear type will give satisfactory service. Most centrifugal pumps have limited suction lifts and should only be installed when a low lift or flooded suction to the pump inlet is available; however there are some self-priming centrifugal pumps available. Suction lifts should be avoided if possible. A vertical turbine type requires a minimum of space and can be installed in the service tank. Rotary pumps can be used where a flooded suction exists or where a suction lift is required.

(b) Pump Motors. Motors must be sized to allow for friction losses in the lines, pumps, filters, valves, hose and fueling nozzle. Motors should be totally enclosed and fan-cooled ball bearing or as required by local codes. Motors should have a service factor of 1.15.

(c) Sizes. High-speed fueling is normally considered fueling at a rate of from 200 to 300 gpm into each locomotive unit. Fueling rate for each individual unit shall be governed by the design of the filling system. Units have fuel oil tanks with capacities up to 8,000 gal and are usually vented for a maximum delivery of around 300 gpm. Capacity of pumps will vary with the number of locomotives to be fueled simultaneously and the fueling rate per hose connection. Discharge pressure should be adequate to provide nozzle manufacturer's recommended pressure, at the inlet of the most remote fuel nozzle, for the discharge rate required. Additional pressure must be allowed for friction loss in line, fittings, valves and hose up to the nozzle inlet.

(d) Number of Pumping Units. The same pump can be used for unloading fuel and fueling locomotives where the facilities are small. Larger facilities are generally equipped with a fueling pump as well as unloading pump or pumps. One or more pumps can be utilized in fueling and pumps can be programmed to come on as the demand increases.

5.8.2.2 Housing of Pumping Equipment

Pumping equipment should be protected from the weather and unauthorized personnel. Turbine pumps can be installed outside on tanks while it is desirable to install rotary and centrifugal pumps in buildings.

5.8.2.3 Pumping Plant Appurtenances and Accessories

(a) Fuel Oil Filters. Diesel fuel should be filtered when it is pumped from storage to locomotive units. Fuel oil station filtration should have a mean flow pore size of 20 to 25 microns. This size filter has a longer life and is adequate filtration before the final filtration on the locomotive before it reaches the injector. A two-stage filter system can also be used where the first-stage filter is a coalescer cartridge for removing water which may get in the oil via storage tank condensation or other means and the second-stage cartridges are for particle filtration.

1. A cartridge-type filter with removable elements is recommended. The capacity should be greater than the maximum pumping rate. For diesel fuel oil, filter should be twice the size recommended for gasoline filtration—the rating filter manufacturer recommends.
2. Pleated paper filters are most generally used, while other types such as cellulose, cotton waste, pressed paper and wood fibre types are available.
3. Replacement of filters is necessary when fuel delivery is too low to maintain the fueling schedule and pressure loss approaches manufacturers recommended limits.
4. A drain system for the filter bowl should be so designed to permit draining the filter bowl and replacing the elements without spillage onto the ground, thus adding to an ever-existing pollution source.
5. Used filters should be disposed of by collecting in leakproof containers and delivery to a local incinerator in the yard or by disposal through a scavenger service.
6. Dual fuel filtering system should be installed to permit continuity of fueling while filter replacement is being made.
7. Filters should be located on the discharge side of the pump, and not on the discharge side of the bypass in the fuel system.

(b) Strainers. A 30-mesh strainer should be installed on the upstream side of all meters, control valves and pumps to prevent damage by foreign matter.

(c) Meters. A meter should be installed in the discharge line to the fuel facility. Some railroads provide separate meters at each fuel outlet.

1. Meters should have a capacity greater than the maximum fueling rate.
2. Rotary positive displacement type meters are accurate, cause little resistance to line flow and are generally suitable for railroad diesel fueling. A variety of registers and counters are available, depending on local requirements.

(d) Bypass Piping. A bypass arrangement is necessary for an installation of the magnitude of one required to furnish up to the maximum capacity of the pump used to supply the header dispensing fuel to the locomotives. The relief valve is located on the discharge side of the pump on the upstream side of the filter and is set to maintain a sufficient pressure in the header at the fueling area to permit full fuel delivery to the most remote fuel outlet. Fueling pumps are normally started prior to fueling operations and precautions should be taken to prevent pump and fuel heating during this no-delivery period. The first choice for the bypass discharge should be back to the service or storage tank, but in some instances may go back to the pump suction. The bypass valve should be a hydraulically operated, pilot-controlled, modulating type, activated by line pressure through a pilot control system, opening fast to maintain steady line pressure and closing gradually as locomotive fuel outlets are opened, to prevent high pressure surges in the pump system. Bypass piping design should include measures to prevent hydraulic hammer in the system.

(e) Electrical Facilities. The electrical work required for a fuel oil pumping plant consists mainly of power supply to building, circuit breakers, starters and a start–stop control system for the pumps. A flow control switch in conjunction with a timer limit switch will prevent personnel from leaving the pump on.

The start–stop control system should be automatic and designed for a fail-safe condition. Recommended types of control are discussed under Art. 5.6.5 and Art. 5.6.6.

5.8.3 Fueling Header

A header of sufficient size is necessary to permit full delivery to all outlets.

(a) Length of Header. Header can be any length to meet locomotive consist to be fueled at one spotting. Pump horsepower is directly dependent on size and length of header and number of units to be fueled.

(b) Pressure in Header. Pressure is necessary to maintain fuel delivery at the most remote outlet. Pressures of between 50 psi and 75 psi are generally sufficient to provide adequate flows. A pressure reducing valve can be installed at each outlet to provide nozzle manufacturer's recommended pressure to the fuel nozzle. A second method would include pipe line pressure control at the filter discharge with header piping sized so that friction losses are almost negligible.

5.8.4 Delivery to Locomotives

5.8.4.1 General

(a) Diesel locomotives are fueled as they enter or leave the diesel shops and at certain main-line stops. The fueling point outlets are installed in conjunction with other servicing facilities, such as for water and sand. Their location with respect to the other facilities depends on the type and number of diesel units regularly serviced.

5.8.4.2 Fuel Outlets

(a) Spacing. Fueling outlets should be spaced to handle the various classes of locomotives to permit one-spot fueling. Outlet spacing varies from 15 to 60 ft. Each outlet should allow between 1 and 2 ft overlap to eliminate moving of a locomotive consist after being spotted for fueling. Outlets properly spaced and counterbalanced will enable the laborer to make quick, positive connections to the locomotive fuel tank.

(b) Valves. A quick-opening quarter-turn plug type valve should be installed between the header and pressure-reducing valve for emergency shutoff in case of hose rupture or nozzle and coupling coming loose or failing to close. The valve should also have internal pressure relief to operate at slightly higher than normal header pressure to relieve any locked pressure buildup between valve and closed nozzle due to locked in line pressure and fuel expansion due to temperature rise.

(c) Hose. Final delivery of fuel oil to locomotives is made using 2 to 2½ inches ID hose, maximum working pressure between 100 and 125 psi. Hose should be no longer than necessary with proper counterbalanced arrangement to keep hose and nozzle off of the platform and give the employee a safe lightweight maneuverability in properly making quick quarter-turn connection of nozzle to locomotive fuel tank connection.

(d) Nozzles. Automatic shutoff nozzles should be used in all fueling operations including normal or low flow as well as high speed. Adequate protective devices should be included in the design to prevent nozzle damage through rough handling.

5.8.4.3 Fuel Cranes

(a) Crane Masts. These are made up of a 4-inch riser pipe 10 to 12 ft high with a swivel joint and short horizontal extension of 2- or 2½-inch pipe at the top and a drop hose to make the final connection. Swivel joints provide operating flexibility, and the working range is adjusted by the amount of hose used.

(b) Vertical Swing Masts. Another design has the double-swing joint and vertical (pulldown) extension pipe at top of riser, similar to the overhead (dome) unloading connection previously described in Art. 5.6.5.2., except that the hose takes the place of the suction drop pipe. Although more expensive, this type mast provides greater working range with less hose, occupies less space, and has other operating advantages over the crane type mast.

(c) Hose. At locations where an overhead manifold supported at 6 to 8 ft above ground is installed, hose outlets on the bottom and spaced as required will permit use of relatively short hoses in fueling locomotives. Dummy fueling connections can be placed on manifold supports to hold nozzle out of the dirt and to prevent it from damage when not in use.

5.8.4.4 Fuel Spillage

Employees fueling locomotives should be adequately indoctrinated in their jobs with complete understanding of automatic fueling and should be held responsible for any spillage occurring. There should be a means to detect spillage at the end of each shift, and proper action taken immediately as to the cause. Proper supervision can eliminate most fuel oil spillage. If the above practice is strictly adhered to, the fuel platform will be a clean safe place to work. Personnel will take pride in seeing that their performance meets the satisfaction of the management.

Report on Assignment 6

Corrosion Control

H. E. Graham *(chairman, subcommittee)*, H. W. Azer, C. E. DeGeer, D. E. Drake, A. E. Dulik, M. F. Obrecht.

Your committee submits as information the following report pertaining to corrosion control in engine cooling systems.

6.5 CORROSION CONTROL IN ENGINE COOLING SYSTEMS

While there are several types of metal attack that may be encountered in a typical diesel engine cooling system, the scope of this report is concerned with corrosion due to water conditions and its prevention by the proper use and control of inhibitors.

6.5.1 Quality of Water

The water used for fill or makeup to diesel cooling systems should be free from materials that could deposit mud, sludge, scale, or cause corrosion in the cooling system.

6.5.1.1 It is desirable that the total hardness does not exceed 35 ppm as $CaCO_3$; however, water containing hardness up to 170 ppm may be used satisfactorily with appropriate treatment.

6.5.1.2 Distilled, de-ionized, zeolite softened water, or condensate are, with proper inhibitors, recommended for fill or makeup purposes.

6.5.1.3 Natural waters exceeding 170 ppm total hardness should be treated externally to reduce the hardness to 35 ppm or less.

The most common methods used to reduce the hardness are zeolite softening or deionization.

6.5.2 Chemical Concepts

Chemical treatment in diesel engine cooling systems is recommended to prevent and/or control the formation of scale and damage due to corrosion. Inhibitors are available which protect the metallic components of the cooling system from corrosion without adverse effect on non-metallic components and without affecting the heat transfer properties of the metal. Some inhibitors also contain scale suppressants to minimize deposits which may result from use of waters containing hardness.

The two types of inhibitors most commonly used are the chromate type and the borate–nitrite type; however, due to waste-disposal restrictions with these inhibitors, new types are being developed by the water treating companies serving railroads. These systems will provide adequate protection of the cooling system provided proper concentration of the inhibitor is maintained at all times and the cooling system is properly maintained.

6.5.2.1 The chromate inhibitor is generally acknowledged to be the most effective and the most economical, due to lower dosage requirements. This inhibitor has a distinct yellow color that also aids in the detection of water leaks. The minimum treatment level to be maintained in the cooling system is approximately 2100 ppm as sodium chromate with higher levels for certain types of engines, particularly those prone to cavitation-type attack.

A disadvantage of chromate is that it presents waste-disposal problems. Practically all states now have a maximum limit on hexavalent chrome of 0.05 ppm expressed as Cr in wastewater discharged into streams, and there are also restrictions on discharging chromate into a municipal sewer system. While chemicals are available to convert hexavalent chromium into trivalent form which can be precipitated out of the wastewater, this treatment of the waste is complicated and somewhat expensive. Reclamation systems have proven economical in reclaiming chromate-treated cooling water for re-use.

Exposure to chromates may cause dermatitis with some individuals and suitable precautions should be taken to protect employees against chromate dust and chromate solutions.

The chromate-type treatment is not compatible with antifreeze solutions.

6.5.2.2 The borate–nitrite inhibitor requires a higher use concentration to be effective and generally tighter control is required to maintain satisfactory results. The normal recommended dosage is approximately 5600 ppm for the drv product, and 2.0 fluid ounces per gallon for the liquid borate–nitrite inhibitors. The borate–nitrite inhibitors are compatible with antifreeze solutions and they present minimum dermatitis hazards. The disposal of the borate–nitrite compounds is generally less restrictive than the chromate. In some areas, the boron concentration is limited to a maximum of 1 ppm when discharged into streams or municipal sewers.

6.5.2.3 Non-chromate, non-borate corrosion inhibitors have been developed for use where chromate or boron-based products cannot be tolerated due to pollution or disposal restrictions or because of dermatitis considerations. These inhibitors include the all-organic type and those containing sodium nitrite as its principal ingredient. The recommended dosages for these inhibitors are 0.6 fluid ounce per gallon of cooling system capacity for the all-organic type and 1000–2000 ppm of sodium nitrite for the nitrite type inhibitor. These types of treatment are compatible with antifreeze solutions.

6.5.3 Testing

There are a variety of test methods available for determining the concentration of the inhibitor in the cooling system. These tests range from conductivity measurements to simple chemical tests. Most chemical companies that supply the inhibitors can furnish test kits, with detailed instructions, for use in any shop or enginehouse.

6.5.4 Summary

Measures to consider in protecting the cooling systems of diesel locomotives from corrosion are:

(a) Good quality of water supply.

(b) Use of a properly compounded chemical inhibitor which is designed to prevent scale formation and inhibit the mechanism of corrosion found in diesel cooling system environments.

(c) Adequate testing with checking done often enough to insure that the recommended concentration of inhibitor is maintained in the cooling system at all times.

(d) Good maintenance of the cooling system.

(e) Proper facilities to insure that all fill and makeup water for cooling systems is adequately protected with recommended inhibitors.

(f) Proper precautions when treatments are used which may cause dermatitis.
(g) Proper precautions to meet state or local regulations when draining cooling systems.
(h) Consideration should be given to the installation of reclamation systems to reclaim the chromate treated cooling water for re-use.

Report on Assignment 7

Noise Pollution Control

W. H. Melgren *(chairman, subcommittee)*, J. J. Dwyer, W. M. Harrison, R. R. Holmes, C. F. Muelder, A. D. Rankins.

Your committee submits, as information only, the following tentative draft of the first part of a new Part 7 of Chapter 13 of the Manual, and invites comments and criticisms thereon.

FOREWORD

Noise is unwanted sound, and has been called the fourth form of pollution. The purpose of this part is to specify guidelines for meeting noise level requirements at property lines of various railroad facilities, and to adequately protect railroad employees' hearing in their many job functions.

CONTENTS

Section Page
7.1 Definitions of Terms ....
7.2 Noise Control Regulations and Codes ....
7.3 Instrumentation ....

7.1 DEFINITION OF TERMS

(a) Decibel (dB)—Unit of sound pressure level, a logarithmic ratio of a given sound pressure level to a specified reference pressure. The decibel scale expresses magnitude of the pressure fluctation on a logarithmic scale, and indicates relative intensity of sounds, rather than an arithmetic loudness scale.

(b) Frequency—A measurement of the vibration of a sound wave associated with the sound's pitch. It is the number of cycles per second of the sound wave, commonly called Hertz (Hz). The human ear responds to approximately 20 to 20,000 Hz.

(c) Pitch—The highness or lowness of sound, depending primarily upon the frequency.

(d) Sound Level Meter—An instrument, including a microphone, an amplifier, an output meter calibrated in decibels, and frequency weighting networks, for the measurement of noise and sound levels in a specified manner. The "A" scale (dBA) approximates the human ears' response to a variety of noises and has been adopted as standard in the Federal Occupational Safety and Health Administration (OSHA) regulations.

7.2 NOISE CONTROL REGULATIONS AND CODES

7.2.1 State and Municipal Codes

State and municipal codes are largely in the formative stage with regard to noise level requirements at industry property lines. Each location must be treated individually.

7.2.2 Federal Codes

Under the Occupational Safety and Health Act of 1970 the Department of Labor established comprehensive Occupational Safety and Health Standards covering most industrial jobs. The OSHA standard applicable to noise exposure is given below:

Duration per Day, Hours	*Sound Level, dBA, Slow Response*
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

Railroads are covered by safety regulations administered by the Federal Railroad Administration.

REFERENCES

(1) Occupational Noise Exposure, Sec. 1910.95, p. 10518, *Federal Register*, May 29, 1971, Vol. 36, No. 105, Part II.

7.3 INSTRUMENTATION

7.3.1 Sound Level Meter

(a) Meter should meet requirements of current American National Standard Institute Specification for Sound Level Meters, ANSI S1.4—1971 Type 1—Precision, Type 2—General Purpose, or Type 3—Survey. The choice of instrument should be guided by the degree of precision required for the intended application.

(b) Meter should be provided with a certified calibration unit and checked frequently.

(c) Meter has capabilities of measuring total sound at its location if the sound is steady—i.e., if its fluctuations are not rapid, as from an impact or impulse noise.

(d) Several instrument manufacturers, both American and foreign, supply meters meeting above requirements.

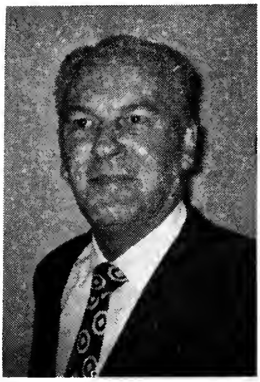
7.3.2 Octave Band Analyzers

More complex instruments are available for in-depth studies of noise problems which incorporate a frequency analyzer to determine the complete noise spectrum by various band widths.

7.3.3 Noise Exposure Monitors

Instruments are available which automatically detect, measure, accumulate, and calculate noise levels present over a preset period and show conformance or nonconformance to applicable noise level requirements. These monitors range from personal pocket-size noise dosimeters worn by the employee to larger units with variable output displays which may be placed unattended at employee work stations.

Report of Committee 14—Yards and Terminals



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(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.

The committee is reviewing the entire material for revision, updating, and indexing to the decimal system. No report included herein.

1. Classification Yards, Collaborating as Necessary or Desirable with Committee 16.

Report on modernization of classification yards, presented as information with recommendation the subject be discontinued .... page 208

2. Scales Used in Railway Service, Collaborating as Necessary or Desirable with AAR Engineering Division Committee on Electrical Facilities—Fixed Property.

A recommended "Definition of a Standard Test of a Motion Weighing Railway Track Scale" is presented for adoption and publication in the Manual in Part 1 of this Bulletin.

3. Length of Freight Cars as Basis for Track Capacity.
   Design data submitted as information with recommendation the subject be discontinued .... page 213
4. Urban Mass Transportation:
   (a) Yards for Storing and Cleaning Passenger Cars.
   (b) Station and Terminal Facilities.
   (c) Parking Facilities at Stations.
   (d) Rail Access to Airports.
   An interesting report supplementing data found in the Manual was presented as advance information in Bulletin 639, September–October 1972.
5. Recent Development in Yard Lighting, Collaborating as Necessary or Desirable with AAR Engineering Division Committee on Electrical Facilities—Fixed Property.
   Final report on this assignment was presented as advance information in Bulletin 639, September–October 1972.
6. New Applications of Computers to Classification Yards, Collaborating as Necessary or Desirable with Committee 32.
   No report.

THE COMMITTEE ON YARDS AND TERMINALS,
G. H. CHABOT, *Chairman.*

Report on Assignment 1

Classification Yards

P. E. VAN CLEVE *(chairman, subcommittee)*, R. P. AINSLIE, J. K. AUST, R. F. BECK, H. R. BECKMANN, A. E. BIERMANN, H. L. BISHOP, E. W. BUCKLES, G. P. BURNS, B. E. BUTERBAUGH, G. H. CHABOT, J. F. CHANDLER, H. P. CLAPP, M. K. CLARK, D. V. CLAYTON, J. A. COMEAU, A. V. DASBURG, F. D. DAY, P. J. DEIVERNOIS, V. H. FREYGANG, J. N. HAGAN, H. L. HAANES, D. C. HASTINGS, L. J. HELD, F. A. HESS, A. L. HUNTER, C. F. INTLEKOFER, J. B. KERBY, C. J. LAPINSKI, J. E. LEMAIRE, S. J. LEVY, W. L. LJUNGREN, E. T. LUCEY, S. N. MACISAAC, J. G. MARTIN, A. MATTHEWS, H. J. MCNALLY, R. G. MOFFATT, W. L. PATTERSON, B. H. PRICE, W. P. RYBINSKI, R. J. SAMOSKA, W. D. SLATER, L. G. TIEMAN, HOWARD WATTS, P. C. WHITE, C. C. YESPELKIS, J. ZAENGER.

MODERNIZATION OF CLASSIFICATION YARDS

Your committee submits this report as information.

The intent of this report is to outline and comment on the equipment and methods which may be utilized to modernize classification yards. While much can be said about modernization of all of the functions and facilities of a yard, this report will be confined to the means of improving the basic operating functions of the yard—the safe and efficient movement of cars through the receiving, classification and departure yards.

Except for the newest, most modern automated classification yards, all of our yards are probably outmoded in some manner. The older yards are outmoded simply as a result of the advent of longer, heavier, and easier rolling cars. Also, changes in traffic patterns and volumes have resulted in less than optimum performance in many of our yards.

A complete study of the yard and its desired functions should be made to determine the modernization requirements. A simulation of yard operations is a useful tool, particularly if extensive changes are required. While much of this report deals primarily with the humping aspects of the yard operation, careful consideration should be given to other vital parts of the yard which are often the determining factor in total yard performance. The inter-relationship of the receiving, classification, and departure yards, the number and capacity of tracks in each yard, and the configuration of turnouts at their entrances and exits are important factors in efficient yard operation. Careful consideration should be given to the design of the trim end of the classification yard, as this is often the crux of total yard performance.

The following is a summary of the inherent problems of the older classification yards, and the equipment and methods which may be used to modernize them:

I. Gradients

A. Hump Gradients

Revision of the hump gradients and hump height may permit faster humping rates. This would usually require improvement in the retarder system. Because of longer cars and modern couplers, it is often necessary to lengthen and flatten the vertical curve at the crest of the hump to facilitate uncoupling. This results in reduction of hump height and is a factor in calculating the hump gradients.

B. Bowl Gradients

A bowl gradient of about 0.08 percent is needed for today's easy-rolling cars to prevent acceleration and high impact speeds. Most of the older classification yards have gradients of about 0.2 percent or more. The normal procedure for reducing bowl track gradients is to raise the tracks, starting near the leaving end of the secondary retarders. Problems which should be anticipated are as follows:

1. The cumulative reduction of track gradient may result in a track raise of 2 feet to 4 feet at the bottom of the bowl. This normally creates a significant problem (and cost) in overcoming this elevation differential at the leaving end of the bowl.
2. The raising of the bowl tracks disturbs the ties and exposes them to the air, which accelerates deterioration. A substantial percentage of tie renewals should be anticipated, which adds considerably to the cost of the project.

II. Retarders

A. Hump End Retarders

Improvement in the retardation system is often needed because of today's longer, heavier, and easier-rolling cars, and larger wheel diameters; the need to hump cuts of several cars for humping efficiency; or because it is decided to change the hump gradients (Par. 1-A) for faster humping rates. The existing retarder system can be improved by the following means:

1. Lengthening or upgrading of existing retarders.
2. Rearrangement of retarder lengths and locations.

B. Retarders at Leaving End of Bowl

New or additional retardation should be considered if runouts are a problem or if reduction of the bowl track gradients (Par. 1-B) will diminish the opposing gradient at the end of the bowl. Types of retardation commonly used are as follows:

1. Inert retarders.
2. Operable retarders.
3. Skates.
4. Skates with automatic controls.

C. Pin Puller Retarders

If difficulty is experienced in pin pulling on the hump, consideration should be given to the installation of a retarder on the hump. This type of retarder is usually push-button actuated, operated by the man who pulls the pins, and provides a slack action to facilitate uncoupling

III. Track Circuits

In many of the older hump yards, the track circuits are short and can be spanned by the longer cars. While this can sometimes be corrected by increasing the length of the track circuits, this usually has the adverse effect of reducing humping speed. This problem can be corrected by addition of presence detectors.

IV. Operational Safety Equipment

The following equipment can be installed on the hump or at the entrance to the receiving yard:

A. Hot box detector.

B. High-wide equipment detector.

C. Dragging equipment detector.

D. Broken wheel/flange detector.

While the yard is a convenient location for these detectors, their installation in the yard is not necessarily essential to an efficient yard operation.

V. Devices for Measuring Car Rollability

There are a number of devices which can be used on the hump to determine the characteristics of single or multiple car cuts, for the purpose of determining proper retardation and exit speeds from the retarders. While most of these devices are computer-connected in automatic hump yards, some can be utilized for the benefit of the retarder operator.

A. Weight Measurement

1. Electronic weigh-in-motion scales

The installation of weigh-in-motion scales ahead of the master retarder will provide one of the devices needed to predict car rollability, and also serve to weigh cars for tariff purposes.

2. Weigh rails

Weigh rails serve the sole function of placing a car in a "light," "medium," "heavy," or "extra-heavy," category for retardation purposes.

B. Speed and Acceleration Measurement
   1. Radar
   2. "Speed" rails

C. Car Dimension Measurement
   1. Photo-electric cells.

VI. Automation

There are several degrees of computer-controlled automation which can be used to improve the humping operation and the overall yard performance. These are:

A. Analog Computer

This can be used to perform the following functions:

1. Retardation control.
   Controls retardation and retarder exit speeds, utilizing the following programmed information:
   a) Car rollability characteristics obtained from the weight, speed, acceleration and dimension measuring devices outlined in Par. V.
   b) Individual classification track characteristics permanently programmed into the computer. These would include gradient, curvature, turnout configuration, and gage. It may be advisable to conduct tests to substantiate the individual track programming.
   c) Other variables such as weather, cut length, truck spacing and distance to travel.
2. Switching control.
   Automatically control the switches and the routing of cars into the classification yard.
3. Hump engine control.
   Automatically controls the hump engine for the desired humping speed.

B. Digital Computer

The digital computer will perform the same functions as the analog computer. In addition, it can perform paperwork and other functions which cannot be performed with an analog computer, including the following:

1. Furnish performance evaluation and operational reports.
2. Provide a perpetual yard inventory, listing loads, empties, length and tonnage. The inventory can be confined to the classification yard, or it can be broadened to include the receiving and departure yards. In some cases, it might be desired to include the auxiliary tracks (local yard, cleaning, shop, service, etc.) and/or the locomotives and cabooses in the inventory.
3. Provide a consist check, in interface with hump television or ACI.
4. Provide an intercomputer communications unit interface to assist in such functions as billing, industrial switching, work orders, demurrage accounting, and interchange reports.
5. Provide an information storage–retrieval system.

6. Provide a complete yard control program, including selection of receiving tracks to be used, sequence of trains to be humped, selection of classification tracks to be used, determination of what tracks are to be rehumped, determination of departure tracks to be used and schedule of assembly, and determination of road power requirements.

C. Process Control Computer
This computer is basically a digital computer, and it will perform the same functions as the digital computer. However, it is equipped with analog-digital conversion equipment, which permits it to accept analog signals, convert them to digital form, process them and then convert the processed data to analog form for more precise control of the car routing and retardation.

D. Back-up and Over-Ride Systems
Computer controlled hump operations are usually provided with an automatic or semi-automatic back-up system. Also they are normally designed so that the retardation and switching system can be overridden and manually controlled when required.

While this report deals primarily with improvements applicable to hump yards, some of the equipment and methods can be applied to advantage in flat yards as well.

Report on Assignment 3

Length of Freight Cars as Basis for Track Capacity

B. H. Price *(chairman, subcommittee)*, J. K. Aust, R. F. Beck, H. R. Beckmann, A. E. Biermann, H. L. Bishop, R. E. Bredberg, H. E. Buchanan, C. M. Burnette, B. E. Buterbaugh, G. H. Chabot, J. F. Chandler, H. P. Clapp, M. K. Clark, E. H. Cook, P. J. DeIvernois, Jr., H. L. Haanes, D. C. Hastings, C. F. Intlekofer, D. B. Kendall, A. S. Krefting, S. N. MacIsaac, Alexander Matthews, Jr., H. J. McNally, R. E. Metzger, W. L. Patterson, J. M. Randles, W. D. Slater, C. E. Stoecker, Jack Sutton, K. D. Tidwell, A. J. Trzeciak, P. E. Van Cleve, Howard Watts, Jr., C. C. Yespelkis, J. R. Zebrowski.

Your committee submits this report as information with the recommendation that the subject be discontinued.

The data for this report were taken from "The Official Railway Equipment Register" and represents 1,676,111 cars owned by 42 railroads and 8 private car companies in the United States and Canada.

The trend to longer cars over the last 20 years is shown in Table 1.

Table 1—Trend in Freight Car Lengths

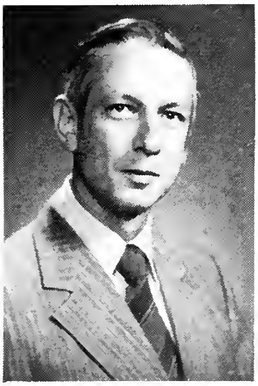
Year	*No. of cars sampled*	*Maximum Length*	*Minimum Length*	*Average Length*
1949	771,729	74 ft 3 in	31 ft 1 in	43 ft 0 in
1960	1,669,046	124 ft 3 in	24 ft 0 in	44 ft 9 in
1972	1,676,111	128 ft 10 in	12 ft 9 in	50 ft 5 in

A more detailed summary of the results of this study is shown in Table 2. (See next page.)

TABLE 2—LENGTH OF FREIGHT CARS

Type of Cars	*Location*	*No. of Cars Sampled*	*Max. Lgth Ft*	*Max. Lgth In*	*Min. Lgth Ft*	*Min. Lgth In*	*Aver. Lgth Ft*	*Aver. Lgth In*
All Cars	East	529,185	124	3	27	6	48	5
	South	273,997	113	5	24	0	48	4
	West	559,285	128	10	12	9	50	0
	Canada	175,564	96	6	24	0	47	6
	Private	138,080	97	6	35	3	69	4
	Summary	1,676,111	128	10	12	9	50	5
Automobile	East	686	93	8	55	3	77	6
	South	42	95	9	67	11	90	9
	West	3,673	96	6	42	4	71	3
	Canada	2,033	93	8	44	4	91	9
	Private	19,057	93	10	85	8	93	4
	Summary	25,491	96	6	42	4	88	11
Box	East	163,421	94	0	34	9	51	11
	South	99,005	94	11	40	2	51	0
	West	261,374	98	8	32	6	49	1
	Canada	104,368	94	0	39	6	45	4
	Private	0						
	Summary	628,168	98	8	32	6	49	6
Flat	East	12,639	124	3	31	8	57	2
	South	7,926	113	5	24	2	58	4
	West	32,440	114	8	41	3	56	11
	Canada	10,243	96	6	35	5	53	6
	Private	6,193	97	6	44	6	71	1
	Summary	69,441	124	3	24	2	57	11
Gondola	East	86,111	71	2	27	6	55	6
	South	28,488	70	8	40	3	50	7
	West	68,842	90	9	24	0	51	10
	Canada	19,656	70	9	28	0	53	2
	Private	1	85	0	85	0	85	0
	Summary	203,098	90	9	24	0	53	4
Hopper	East	220,004	85	3	32	3	42	3
	South	75,279	73	0	24	0	42	8
	West	61,622	59	5	21	6	39	2
	Canada	14,193	54	9	24	0	41	4
	Private	0						
	Summary	371,098	85	3	21	6	41	10
Covered Hopper	East	28,675	68	4	31	4	45	4
	South	31,021	68	10	31	6	46	11
	West	68,165	62	3	29	10	47	8
	Canada	9,475	59	7	32	1	50	7
	Private	14,698	94	4	35	3	50	0
	Summary	152,034	94	4	29	10	47	6
Piggyback, Flexi-Van	East	5,599	95	8	41	5	62	5
	South	370	57	1	45	4	53	8
	West	4,910	128	10	42	0	76	9
	Canada	3,266	88	2	44	10	53	5
	Private	41,716	97	6	49	0	90	11
	Summary	55,882	128	10	41	5	84	4

Report of Committee 16—Economics of Plant, Equipment and Operations



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* Died September 6, 1972.
(E) Member Emeritus
Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.
During the past year, work has continued on preparation of Part 4, Operations, of Manual Chapter 16. A section on electrification is to be included in this part and some of the material on electric locomotives in Part 2 will be moved to Part 4. An outline has been prepared for Part 6, Industrial Engineering.

1. Study Optimum Length, Speed and Weight of Freight Trains Under Varying Traffic and Competitive and Operating Conditions Relating to (a) Balanced Trains, (b) Long Train Operation, and (c) Short Train Operation.
A report on this subject was published in Bulletin 639, September–October 1972, with the recommendation that this assignment be terminated.

2. Engineering Methods and Economic Considerations Involved in Improving the Quality of Transportation Service.

   An outline has been prepared but progress has been limited to efforts to define and limit the scope of the assignment.

3. Determination of Factors, Including Various Traffic Volumes, Affecting Maintenance of Way Expense, and the Effect of Using Such Factors, in Terms of Equated Mileage or Other Derived Factors, for Allocation of Available Funds to Maintenance of Way, collaborating as necessary or desirable with Committees 11 and 22.

   The approach to the assignment has been changed from attempting to correlate historical expenditures with traffic volume to attempting to isolate, qualify and study the individual characteristics of rail transport that contribute to maintenance of way expense. A report with the new emphasis is now being prepared.

4. Economic Evaluation of Methods for Reducing the Probability of Derailments.

   An outline has been prepared and data are being collected, but no information is yet ready for publication.

5. Economics of Freight Cars with Characteristics Approaching the Limits of Accepted Designs.

   An outline for this new assignment has been developed, but no information is yet ready for publication.

6. Factors Involved in Rationalization of Railway Systems.

   At present, the limits of this new assignment are being defined and an outline is being prepared. A report should be ready for publication in 1973.

7. Applications of Industrial Engineering Functions to the Railroad Industry.

   The subcommittee is collaborating with Subcommittee B in preparing material for Part 6 of Manual Chapter 16 and is making a survey of standards applications in the railroad industry.

8. Economics of Systems for Control of Train Operation.

   So far, little progress has been made on this new assignment.

THE COMMITTEE ON ECONOMICS OF PLANT, EQUIPMENT AND OPERATIONS,
WM. G. BYERS, *Chairman.*

Report of Committee 22—Economics of Railway Construction and Maintenance

R. W. Pember, *Chairman*
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Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.
No report.

1. Analysis of Operations of Railways That Have Substantially Reduced the Cost of Construction and Maintenance of Way Work.
Progress report, presented as information .... page 218

2. Economics of Methods and Procedures for Disposal of Discarded Cross Ties.
A report on this assignment was presented as advance information in Bulletin 639, September–October 1972.

3. Economics of Producing Continuous Welded Rail by In-Track Welding.
No report.

6. Economies to Be Realized from the Use of a Two-Rail Method of Laying and Picking up Rail with a Rail Train Versus the One-Rail Method Being Used by a Majority of Roads.
   No report.

THE COMMITTEE ON RAILWAY CONSTRUCTION AND MAINTENANCE,
R. W. PEMBER, *Chairman.*

Report on Assignment 1

Analysis of Operations of Railways That Have Substantially Reduced the Cost of Construction and Maintenance of Way Work

M. H. DICK *(chairman, subcommittee)*, W. S. AUTREY, S. A. COOPER, W. J. JONES, H. W. KELLOGG, W. E. LAIRD, GUY LILJEBLAD, C. T. POPMA, R. W. PREISENDEFER, W. B. THROCKMORTON, G. H. WINTER, T. P. WOLL.

This report is submitted as information. It deals with the Kansas Test Track which is a research project sponsored jointly by the Federal Government, represented by the Federal Railroad Administration of the Department of Transportation, and the Atchison, Topeka & Santa Fe Railway. The Santa Fe has acted as the prime contractor for the project. In progressing the various aspects of the project it has worked through task orders under a basic ordering agreement between the railroad and the FRA.

W. S. Autrey, chief engineer of the Santa Fe System, is exercising general supervision over the project for the railroad. W. S. Tuinstra, engineer of special projects for the Santa Fe, is the railroad's direct representative in all matters relating to the project.

What is being sought in the Kansas Test Track, in words of Kenneth Lawson, chief of the Rail Systems Division of FRA's Office of Research, Development and Demonstration, "is a type of track structure that will have the ability to maintain its geometry and its resilience for longer periods under greater stress than contemporary track may be able to."

In a report on the test the FRA stated that "the purpose of the venture is to determine the cost-benefit relationship of several methods of improving upon traditionally designed, conventional railroad track. Subjected to study will be several concepts of rail support offering the promise of greater stability under rolling loads and longer-term retention of this desirable characteristic than is possible of achievement with contemporary track design."

In an address before the March 1972 convention of the AREA, W. B. O'Sullivan, staff engineer, Rail Systems Division, FRA, said the Kansas Test Track has, as its major objective, "the determination of relative stability exhibited by four distinctly differing levels of train support stiffness." He described the test in more detail in these words:

"The four structural systems embodying these separate levels of guideway stability are, in order of descending stiffness: (1) Three sections including a reinforced concrete slab, continuously reinforced concrete twin beams, and precast, reinforced concrete twin beams; (2) a segment referred to as the stabilized ballast section which incorporates standard Santa Fe main-track design as to wood tie spacing and ballast depth but having had the ballast fully treated with an emulsified elastomer gripping the ballast particles at points of contact in an elastic manner rather than imparting rigid stiffness; (3) four sections of concrete ties representing three center-to-center spacings (30 in, 27 in and 24 in) and two below-tie ballast depths of 10 and 15 in; and (4) a section on standard Santa Fe mainline track to serve as a control." The rail through the test track is the 136-lb RE section welded, which is standard for this Santa Fe territory.

Site Selection

In selecting a site for the test section a primary consideration was the need for a location of high speeds and heavy traffic and with suitable subgrade conditions. A site meeting these requirements was found on a single-track main line of the Santa Fe near El Dorado, Kan., about 40 miles northeast of Wichita, Kan. Traffic here is about 50 million gross tons per year and train speeds of up to 79 mph for freight trains. This location was chosen in preference to another candidate site that had been suggested in eastern New Mexico.

In a discussion of the objectives of the test, Kenneth Lawson said that specific components are not the subject of the test. He added: "It is the over-all functional concept which is the subject of the experiment. In furtherance of this concept it was necessary to use the same concrete tie in all four test sections involving such ties . . . The tie chosen will be selected for its over-all dimensions, its ability to provide a functional member in a total system, and there will be no inference that the products not used are in any way considered inferior."

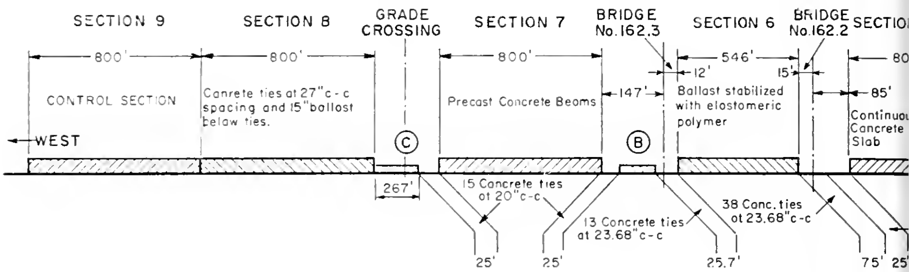
The concrete tie chosen for the test is a monoblock, prestressed tie manufactured by the long-bed method. The fastening throughout is of the threaded clip type and the rails are separated from the ties by 6-in by 9-in elastomer pads.

General Features

The test section was constructed on an alinement parallel with, and 30 ft north of, the existing main track. State route 177 parallels the test track on the north side. The test track was cut into the main line by means of temporary No. 14 turnouts at each end to facilitate track construction and observe initial performance of the test track under traffic before final line over. The alignment is tangent throughout and the grade ranges from 0.38% to 0.41% descending to the west.

The test section has a length of about 8000 ft and lies between Mileposts 161 and 163. Arrangement of the nine test sections is shown by Fig. 1. With one exception the test sections are 800 ft long. The exception is the section with stabilized or "glued" ballast. Because of unavoidable site dictates, this section was made 546 ft long.

The segment length of 800 ft was arrived at by reference to data acquired in an investigation of freight-car vibration carried out by FRA with the Chessie System. The reasoning was based on the desirability that each car of a train consist be responding, in the vicinity of instrumentation, to the test segment being observed and not retain evidence of earlier stimulus. This effect, it is explained, is largely diminished by the choice of 800 ft as the segment length and the prescribed location, within this distance, of the main instrumentation.



A contract for design of the embankment and the instrumentation to be installed in it was awarded to the consulting firm of Shannon & Wilson, Inc. The principal design objective was to produce uniform support of good quality for the test-track structure using locally available materials. The survey work done by the consultant included vibration measurements at various locations along the existing embankment. Their purpose, as explained in a report by the consulting engineer, "was to determine the general embankment response characteristics to rail loading to assist in establishing the required minimum thickness of the embankment and to determine the range of dynamic response for design of project instrumentation."

Features of the Embankment

The standard Santa Fe embankment section was selected for the test track. A minimum embankment thickness of 6 ft was adopted. This decision was reached primarily on the basis of the vibration measurements which, the report said, "suggested a need for an embankment well in excess of 3 ft to minimize vertical embankment response and on the basis of engineering judgment."

Suitable embankment was obtained either from the site or from borrow pits. Where necessary to provide the minimum embankment thickness of 6 ft, existing rock was excavated and wasted. Compaction criteria (92%) were established and observed in constructing the embankment. To avoid the consequence of strength loss in the embankment due to frost action the top 6 in of subgrade have been treated with a 3% lime admixture and sealed with cutback asphalt.

In preparation for placing the various test segments, 6 in of Pueblo blast-furnace slag ballast was placed on the subgrade and compacted by rolling. At Section 8, where the specifications call for 15 in of ballast under the ties, 11 in of compacted ballast was placed. The additional 4 in of ballast required under the various sections was placed after the track had been laid.

At Section 6, where the specifications call for the ballast to be stabilized with an elastomeric polymer, the treatment was applied to the compacted ballast layer, with the intention of treating the remainder of the ballast section after it was placed. The procedure is first to spray the ballast with a solution of agricultural ammonia and then to apply the elastomer emulsion. The result is that the elastomer is deposited as a binder at the points of contact between the ballast particles.

The concrete beams and slabs were designed under contract by Westenhoff & Novick, Inc., Chicago. These include the continuous cast-in-place concrete slab for Section 5, and the precast concrete twin beams for Section 7. It is noted in the FRA report on the test track that "the inclusion of precast beams in this study

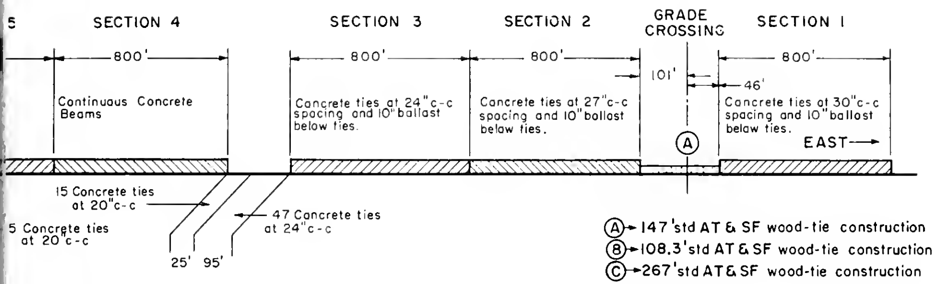


Fig. 1—The Kansas Test Track consists of eight test sections and a control section.

is suggested for the case of installation in working track, avoiding long out-of service periods for curing." It is further noted that the slab and beams "may be anticipated to be very satisfactory performers—while suspect economically in terms of present-day loadings and speeds."

Fastening for Slabs, Beams

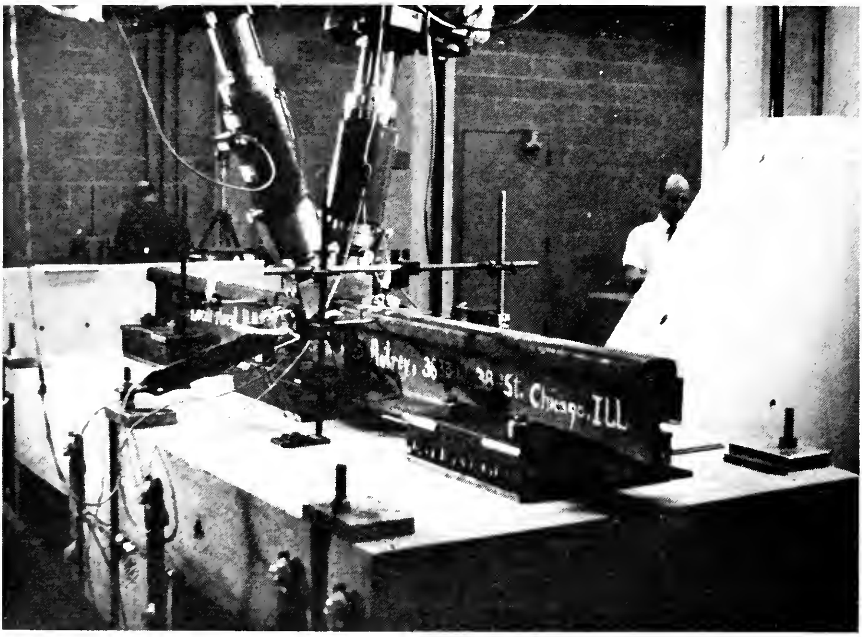
A direct-fixation fastening was selected for use throughout the concrete beam and slab sections. This fastening is a highly engineered and complex assembly. Essentially the fastener consists of steel shims underneath a steel channel which contains a butyl rubber base pad, butyl rubber clips on the top of the rail base, gage blocks and shims for lateral adjustments, and special nuts and washers bearing on a steel clamping plate. This assembly is supported on an asbestos-cement panel embedded in the concrete and is secured by means of high-strength bolts fastened in the concrete by plastic anchors.

This fastening is designed to be adjusted laterally through a range of plus or minus ¼ in. in increments not larger than ⅛ in. It is capable of being adjusted vertically through a range of plus ¾ in and minus ¼ in. in ⅛-in increments, with the final adjustment to be no coarser than $\frac{1}{16}$ in.

Instrumentation

As explained by Mr. O'Sullivan, the instrumentation for each of the nine test sections is approximately similar and is comprised of:

(1) In the embankment
   (a) Vertical and lateral extensometers to determine soil strains produced by stress application.
   (b) Moisture and temperature sensors.
   (c) Load cells (at various depths and at the ballast interface).
(2) In the track structure
   (a) Rail and tie strain gages.
   (b) Rail and tie accelerometers.
   (c) Rail and tie displacement transducers.
   (d) Tie-ballast interface pressure sensors embodied in a unique load-cell tie developed for this project by the Cement and Concrete Institute of the Portland Cement Association.
   (e) Rail-bearing sensors either as part of the load-cell ties or, as in the case of the rigid-support systems, as a vertical and lateral load-sensing element supporting a fastener.



Repeated load test of fastener used throughout the beam and slab sections of the Kansas Test Track.

The need to incorporate instrumentation in the embankment is based on the reasoning that it is necessary to observe the embankment response in order to evaluate the performance of the track structure. Of primary interest is embankment stress and strain under dynamic loading. However, the FRA report notes, it is very difficult to obtain valid stress measurements in earth so emphasis is placed on obtaining reliable measurements of strain.

Each of the nine test sections has a principal instrument array in the embankment. The main arrays are supplemented by additional instruments spaced throughout the test section to verify that the performance of the embankment at the main array is typical of the particular test section.

The main array in each test section has been positioned near the west (downgrade) end on the premise that measurements will be made principally under westbound rail traffic which is the preponderant movement. Specifically, the main array is placed at the 600-ft point in each of the test sections except, of course, for the section with stabilized ballast where it was placed 400 ft from the east end.

For measuring the embankment strains, Shannon & Wilson, who designed the embankment instrumentation, adopted a strain-measuring system utilizing linear, variable, differential transducers (LVDT) for sensing permanent and transient deformations. This equipment will measure displacements directly, and recording equipment may consist of digital readouts or pen or oscillograph-type chart recorders.

Placing cationic emulsion in the ballast in Section No. 6. The result is to produce a rubber-like cementing agent between the ballast particles.

The embankment instrumentation was incorporated in the fill during construction. At the location of each main array there are three multiposition vertical extensometers anchored in rock, one in the center of track, one under the north rail and one four feet from the north rail. The purpose of these is to measure vertical embankment strain relative to the surface of the subgrade. In addition four single-position vertical extensometers were installed at other points in each section except for the short section. These, all underneath the track centerline, are placed at the 300-ft, 400-ft, 500-ft and 700-ft points in the section measured from the east end and provide verification of main array output.

At the location of each main array, provision for the use of horizontal extensometers has been provided in the form of horizontal 4-in corrugated polyethelene tubing placed at four levels. This tubing has PVC couplings placed at 2.5-ft and 5-ft intervals, which are anchored in the embankment. Strain rods with a hooking device will be used to measure the static horizontal deformation of the embankment at the location of the tubes. One set of strain rods will be used for taking measurements at all the tubes. Dynamic horizontal deformations in the tubes will be measured with portable extensometers.

Other instrumentation at the main array locations includes three pressure cells in the upper portion of the embankment. These are flat, fluid-filled stainless steel cells approximately 6 in. in diameter and ½ in thick. An LVDT pressure transducer

Depositing concrete ties on the roadbed of the test section.

is attached near each cell and electrical leads extend to an external terminal box for readout purposes.

Also at the location of each main array there are 13 moisture-temperature sensors. These cells are expected to provide qualitative and possibly quantitative information on variations of water content and temperature in the embankment with time. This information will be used to correlate with measured strains in the embankment and other aspects of embankment and track structure performance.

With the exception of the moisture-temperature cells, the embankment instrumentation has been designed specifically for this project. Wherever possible, however, existing equipment has been adapted or stock components utilized.

The Cement and Concrete Institute of the Portland Cement Association was awarded the contract for design and installation of above-foundation instrumentation and subsequent data collection and analysis. Insofar as the cross-tied portions of the test are concerned, this instrumentation is designed to provide information on the following:

A. Distribution of wheel loads to ties for various spacings.

B. Impact factor due to moving loads.

Looking west from concrete tie section No. 8 to Section No. 9 which is built with wood ties according to Santa Fe standards.

C. Distribution and magnitude of support reaction to bottom of ties at various spacings and changes due to traffic and time.

D. Amount of torsion produced in concrete ties, and track conditions responsible for torsion.

E. Rail stress for the several tie spacings.

F. Vertical movement of crossties and rail.

An important part of the instrumentation is centered in special load-cell ties that were installed in each of the crosstie test sections. The load-cell ties for use in the concrete and wood tie sections have approximately the same stiffness as the adjacent ties and the part of the load cell tie contacting the ballast is the same size as the adjacent ties. Rail fasteners and pads identical to those of the concrete ties are used with the load-cell ties. Also the dynamic structural response of the steel tie is intended to be identical with that of the tie being simulated. Hence, the measured reactions on the load-cell tie should be directly comparable to those on the other ties.

Reinforcing in place for cast-in-place concrete beams. Light-colored areas are locations where plastic sheathing was placed to cause the concrete to crack purposely as a means of preventing cracks at unwanted locations.

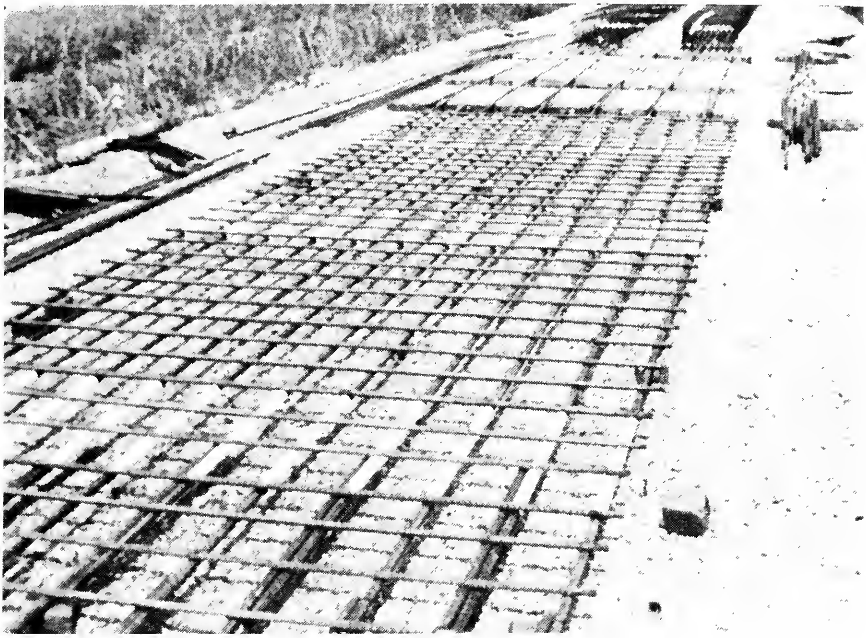
The load-cell tie is described essentially as a steel box divided into 10 sections of equal length. A ballast contact shoe at each of the 10 sections is connected to the structure of the tie through a load-measuring cell. At each rail seat the connection to the tie structure is also made through a load-measuring cell.

Instrumentation of the load-cell ties and also of certain concrete ties will make it possible to measure all forces that go into the ties, including the pressure at the interface with the ballast, distribution of the pressure along the bottom of the tie over a period of time and the bending moment under the rails and at the center of the tie.

Torsion and bending of the concrete ties will be measured through the use of strain gages. Oscillograph recorders producing a permanent ink trace on paper will be used to record the strains and also tie deflections, accelerations and the output of force-measuring cells in the load-cell tie. Acceleration data up to 1,000 Hz will be recorded on magnetic tape.

Stresses in the rails will also be measured through the use of strain gages. These gages will be so placed as to sense the maximum bending due to wheel loads. Deflections will be sensed with electrical transformers that will have one end attached to a tie or rail and the other to a reference rod.

Instrumentation in the slab and beam sections consists of deflectometers for measuring deflection, soil-pressure cells at the interface of the soil and the beams or slabs, pressure transducers under the rails, strain gages on the rails, and strain gages for measuring stresses in reinforcing bars.



Bottom reinforcing steel in place for cast-in-place slab. Note that plastic tubing was also used here to control cracking.

Construction Timetable

The construction timetable called for traffic to be routed over the test track in November 1972. The plan was to put traffic over the test track at a speed of 30 mph for 14 days to check out the track and to see how it is holding up. The DOT track-measuring car was to be run over the track which will be lined and surfaced according to the car measurements. Stabilization of the remaining ballast in Section 6 will be done at the time this work is performed.

The track was then to be opened for traffic for another 14 days during which train speeds will be increased gradually until the regular speeds have been reached.

Inspections, Data Collection

Following a period of stabilization of the test track it was expected that inspection and observation of the track will be carried out on at least a seasonal basis, that is, four times a year. The expectation is that the DOT track-measuring car will play a part in these observations, along with readouts from the instrumentation. The measuring cars will record both ride response and track geometry data, section by section.

Tentatively at least, the plan is to collect data from the instrumentation over a three-year period, four times the first year and during the next two years at intervals to be determined at a later date. The concepts that prove successful in this test project will, it is expected, be tested further on curved track on more substantial grades.

Statement of Purpose

The reasoning behind the Kansas Test Track was outlined in a statement furnished to the committee by Robert C. Arnlund, civil engineer of the FRA. "The Kansas test track" he said, "is a carefully engineered facility intended to demonstrate several levels of incrementally improved train support. From intensive observation of comparative performance of the nine test sections it will be possible to determine not only the gross behavior of each section, but also the causal factors leading to these phenomena and the way in which the components of each section contribute to total performance.

These observations will provide the following:

"(1) Basic knowledge on the performance of each major element of track structure for both conventional and non-conventional support systems.

"(2) A comparison of construction and maintenance costs for various track support systems (Improvement of ride quality as measured by DOT Rail Research Cars, can give an indication of additional benefits to vehicles and lading, an aspect that must be included in any consideration of the complete foundation-track-vehicle system).

"(3) Validation and calibration for theoretical work currently underway (i.e. the essential, first-step development of mathematical models for track stability analysis).

"(4) Concrete tie response data to verify AREA preliminary design specifications and aid in further refinement.

"(5) Information on track-stress distribution necessary to the formulation of further analyses on optimizing track stability and thereby realizing a reduction of maintenance costs.

"(6) The data base necessary for selection of further tests to study the effects of high lateral and tractive loadings resulting from curves and grades. Test to be similar to the present Kansas Test Track.

"Information gained from this test and future tests will produce a greater rational understanding of track design, performance and maintenance resulting in greater economies in track, vehicles and operations."

Significance of Kansas Test Track to Railroads

Prior to assessing any potential benefit likely to come out of the Kansas Test Track studies, it might be well to inquire into the railroads' attitude concerning this project. Do the railroads agree that a change should be made in our track structure design? Should the government play a dominant role in this undertaking? Will the test, as now conceived, provide meaningful data leading to an alternative design that is both practical and economical?

Your committee believes that many railroad representatives agree that the conventional track structure needs to be improved. It is a well-established fact that the present-day track, consisting of CWR spiked to timber ties and supported on at least 8 in of quality ballast, is adequate for trains moving at speeds in excess of those now being operated. Also, it is a well-known fact that such track structure is capable of carrying heavy tonnage trains hauling cars with high axle loads. What is not known is how many more years our conventional track design can effectively serve the needs of our industry.

Track men are becoming increasingly concerned over changes in the design of cars and locomotives which have proceeded at a fast rate, without any regard for the impact on the track structure. Additionally, the prediction that our railroad traffic volume will double by 1985 gives cause for concern.

Obviously, if a change is to be made in the design of our track structure, such changes should be based upon factual information developed through research and tests involving actual train operating conditions. Such tests require time. For the necessary information to be in hand when required, the time to begin the serious investigation is now.

American railroads do not have the amount of in-house research capabilities required to conduct research, install test tracks and collect and analyze scientific data. Moreover railroads lack the funds that are required by such projects. FRA has stated (in Report FRA–RT–72–08) that "strong financially sound rail transportation is an essential part of the economic stability of this country." The same report says: "The government recognizes an obligation to support innovation in the field of track construction and maintenance." Your committee feels that the government action is a proper one and welcomes its participation. It is doubtful that this project could be considered on any other basis.

The Kansas Test Track will produce a wide spectrum of pertinent data. When these data are analyzed and the findings are complemented by the information derived through supplemental tests, we should have an insight into the particular track structure concept which best meets the requirements of "stability of track structure under load" and "ability to retain these characteristics for long periods of time."

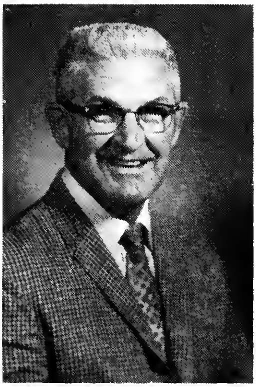
It must be kept in mind, however, that one or more of the systems under test might meet the two prerequisites but still fail to win universal acceptance due to a disproportionately high first cost. Despite this possible drawback, the Kansas Test Track will in all probability be adjudged as being successful, measured by the wealth of knowledge growing out of the study.

Even when considering first cost, certain expensive designs can conceivably become economical when installed at selected locations, viz, chronic spots and in areas where machines cannot be utilized efficiently due to physical restrictions or train traffic density. Through the knowledge developed by observation of the Kansas Test Track it seems reasonable to expect that the data will, at least, point the direction in which the ultimate correct answer lies among the several supporting structures under test, always keeping in mind the question whether the cost can be justified.

There is an urgent need for information, factual and conclusive, on the size of ballast which best supports trackage under moving loads, and the depth required for optimum distribution of loads to the subgrade. Moreover, the cushioning effect of ballast must be analyzed to permit compression and recovery under loads, while at the time shedding moisture and impurities.

It seems apparent to the committee that the initial cost of any of the types of supporting structure under study in the Kansas Test Track will be considerably more than that for conventional track. For this reason it welcomes the information that the FRA is planning to undertake an extensive analysis of conventional cross-tied track. Nevertheless, the committee is convinced that the Kansas Test Track will produce information of considerable benefit to the railroad industry.

Report of Committee 28—Clearances



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Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.

Chapter 28 of the Manual is being reviewed for revision, and for renumbering and indexing in the decimal system.

1. Investigate the practicability of using disposable coded placards for identifying shipments of excessive dimension and/or weight that could be used in conjunction with the Automatic Car Identification System. No report.

2. Compilation of the railroad clearance requirements of the various states.

   The latest tabulation of "Legal Clearance Requirements" was published in Bulletin 636, January–February 1972. Copies of the tabulation may be obtained from Subcommittee Chairman R. D. Erhardt, assistant engineer, Illinois Central Gulf Railroad, P. O. Box 1828, Mobile, Ala. 36624, or Association headquarters.

3. New methods and electronic devices for recording measurements of clearances of structures along right-of-way and overall dimensions of cars and loads in yards and at interchange points.

   No report. Recommendation has been submitted to combine this assignment with Assignment 7.

7. Investigate the feasibility and cost of developing equipment and a contract service arrangement to be made available to any railroad desiring to make a clearance survey of its system.

   See comment under Assignment 3 above.

8. Extend "Table for Computing Curve Offsets on Overhanging Loads," now in the Manual, to accommodate longer loads and longer truck centers, collaborating as necessary or desirable with Committee 32.

   Table for computing curve offsets on overhanging loads has been extended to cover loads up to 300 ft long. Some work is necessary to put the tables into final form. When this has been done, the tables will be submitted to the committee for letter ballot for inclusion in the Manual.

9. Investigate the possibility of including the truck center dimensions of all cars in the Official Railway Equipment Register, collaborating as necessary or desirable with the Mechanical Division, AAR.

   No report. Collaboration by AAR Mechanical Division has been requested.

THE COMMITTEE ON CLEARANCES,
M. E. DUST, *Chairman.*

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American Railway Engineering Association—Bulletin

Bulletin 641
Proceedings Volume 74*

January–February 1973

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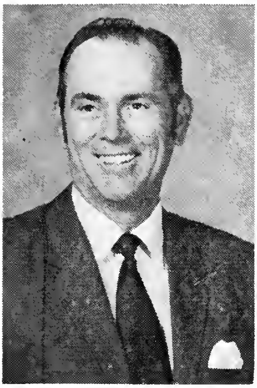
Report of Committee 25—Waterways and Harbors



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Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To The American Railway Engineering Association:

Your committee at the present time has four assignments in addition to assignments A and B. A review of these assignments has resulted in the committee undertaking the task of a complete revision of its Manual chapter.

Using the decimal format, the committee has evolved an outline consisting of 11 proposed parts for the Manual revision, as follows:

Part 1—Project Planning
Part 2—Waterways
Part 3—Harbors
Part 4—Design
Part 5—Dredging
Part 6—Track and Transfer Facilities
Part 7—Materials
Part 8—Construction
Part 9—Maintenance
Part 10—Operation
Part 11—References

The above outline was divided among the present subcommittees for the purpose of formulating a detailed outline of the 11 Parts and finally formulating the detailed terminology of the 11 Parts. The present subcommittees have been assigned the following Parts:

Subcommittee B:

Coordinator of all work on the proposed Manual revision.

Subcommittee 2:

Part 1—Project Planning
Part 10—Operation

Subcommittee 3:

Part 2—Waterways
Part 5—Dredging
Part 11—References

Subcommittee 6:

Part 3—Harbors
Part 4—Design
Part 6—Track and Transfer Facilities

Subcommittee 7:

Part 7—Materials
Part 8—Construction
Part 9—Maintenance

The committee does not intend to formulate a text-type terminology as such but wherever possible terminology will be directed and referenced to existing Manual chapters. Because of this your committee solicits comments and/or recommendations by the other technical committees involved. In addition, as the task is most formidable, your committee welcomes any member to join the committee for a rewarding experience of utilizing his interest and expertise in formulating the forthcoming terminology.

With the hereinbefore introduction, your committee reports on the following subjects:

B. Revision of Manual.

Detailed outline of the proposed Manual revision, submitted as information . . . . page 235

2. Current Policies, Practices and Developments Dealing with Flood Control, Water Conservation, Waterways and Water Navigation Projects.

(a) Progress report, submitted as information, relating to AAR's statement on U. S. Water Resources Council's proposed "Principles and Standards" . . . . page 239

(b) Drafts of Part 1 and Part 10 of the proposed Manual revision, submitted as information . . . . page 258

3. Bibliography Relating to Benefits and Costs of Water Resource Projects of Interest to Railroads in the Areas of Flood Control, Storage, Drainage and Navigation.

Draft of Part 2 of the proposed Manual revision, submitted as information . . . . page 265

6. Planning, Construction and Maintenance of Rail–Water Transfer Facilities.

Drafts of Parts 3, 4 and 6 of the proposed Manual revision, submitted as information . . . . page 267

7. Relative Merits and Economics of Construction Material Used in Waterfront Facilities, Collaborating with Committees 7, 8 and 15.

No report but progress is such that the committee will review a draft at its next meeting.

THE COMMITTEE ON WATERWAYS AND HARBORS,
L. H. McCURRY, *Chairman.*

Report on Assignment B

Revision of Manual

R. L. Bostian, Jr. *(chairman subcommittee)*, S. G. Wintoniak, E. S. Laws, J. M. Bates, B. M. Dornblatt, P. P. Dunavant, J. C. Fenno, R. T. Haggerstrom, A. O. Kruse, E. C. Lawson, F. J. Olsen, R. L. Pettegrew, G. A. Stenstrom.

Your committee is in the process of revising Chapter 25 of the Manual in accordance with the following outline, which is submitted as information.

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(1972 Draft)

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Report on Assignment 2

Current Policies, Practices and Developments Dealing with Flood Control, Water Conservation, Waterways and Water Navigation Projects

JOHN GRESSITT *(chairman, subcommittee)*, R. V. GILBERT, R. C. RANKIN, J. M. BATES, W. E. CORBET, J. C. FENNO, J. H. FITZPATRICK, C. E. GILLEY, R. T. HAGGERSTROM, A. O. KRUSE, M. S. PATTERSON, C. A. STILL, B. H. VOOR.

Under this assignment your committee presents, first, a report by L. H. McCurry, chairman of Committee 25, relating to the AAR's statement on the U. S. Water Resources Council's proposed "Principles and Standards for Planning Water and Related Land Resources," followed by drafts of Proposed Part 1 and Part 10 of Chapter 25 of the Manual, on which comments and criticisms are invited. Part 1 begins on page 258, Part 10 on page 262.

Report by L. H. McCURRY

Chairman, Committee 25
Waterways and Harbors

Your committee submits as information the Association of American Railroads' statement presented to the United States Water Resources Council on the Council's proposed "Principles and Standards For Planning Water and Related Land Resources." Bulletin 636, January–February 1972, pages 477–485, reported as information the remarks of W. Don Maughan, director, Water Resources Council, on the proposed "Principles and Standards . . ." which gave a brief description of the Council's proposal. Bulletin 638, June–July 1972, page 658, reported in Committee 25's chairman's remarks that the complete text of the Council's proposed "Principles and Standards . . ." was published in the December 21, 1971, issue of the Federal Register, Volume 36, Number 245, Part II, pages 24144 through 24194.

The United States Water Resources Council has published a "Summary Analysis of Public Response to the Proposed Principles and Standards for Planning Water and Related Land Resources and Draft Environmental Statement," dated July 1972, which contains excerpts of the AAR's statement. It is Committee 25's opinion that the full text of the AAR's statement is most important information because the subject matter relates the concern of the railroad industry and will be beneficial to those that have an interest in the policy involved.

The AAR's complete statement is as follows:

TO THE
WATER RESOURCES COUNCIL

STATEMENT FROM THE
ASSOCIATION OF AMERICAN RAILROADS

PRESENTING COMMENTS ON THE
PROPOSED PRINCIPLES AND STANDARDS
FOR PLANNING WATER AND RELATED LAND RESOURCES

Introduction

The railroads are concerned with the principles and procedures used to evaluate water and related land resources projects, particularly those involving features for commercial navigation. Therefore, the following presents the Association of American Railroads' views on the Water Resources Council's "Proposed Principles and Standards for Planning Water and Related Land Resources," published in the Federal Register of December 21, 1971, Volume 36, Number 245, Part II, pages 24144 through 24194.

Since the railroads are both important taxpayers and essential common carriers, they have a dual interest in the adequacy of the proposed Principles and Standards. As common carriers, many railroads, including those which serve the upper Mississippi River region, actively compete with both common and private carriers by barge. These railroads, in particular, have a direct economic interest in the principles and standards to be used in evaluating the commercial navigation features of water resource projects for the use and benefit of their competitors, the barge operators. Even those railroads which do not compete directly with waterway carriers may be affected by commercial navigation projects to the extent that industry they currently serve may relocate to areas served by Federal waterway projects to take advantage of low waterway rates subsidized by public tax money. The railroads have a further interest in the proposed Principles and Standards since their tracks and other physical structures necessary for the movement of traffic are often affected by the construction of water resource projects and by flood conditions.

The railroads commented on the following matters raised by or related to the proposed Principles and Standards:

Water Resource Planning Objectives

1. "Well-Being of the People" as the Overriding Objective
2. National Public Objectives for Navigation Projects
3. Regional Development Objective

Evaluation of Water Resource Projects

4. Viewpoint for Economic Analysis
5. Evaluation of Navigation Project Effects
6. Improvements in National Economic Efficiency

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Water Resources Planning Objectives

1. *"Well-Being of the People" As the Overriding Objective*

At the regional hearings on the preliminary Task Force Report of June 1969, the danger was expressed that non-economic and social objectives might be used to justify basically unsound projects for the primary benefit of special interests. Further, that vague and ambiguous objectives such as "social well-being" could be used to generate support for including nebulous benefits as a means of justifying uneconomic projects. The railroads concur with the Council's position that the "social well-being" objective, as defined and proposed in the Task Force Report of July 1970, should not be used in plan formulation.

The requirement in the current planning policy standards (in Senate Document No. 97, 87th Congress) that the "well-being of the people shall be the overriding determinant in considering the best use of water and related land resources" is very different from the ambiguous "social well-being" objective which does not appear in the Proposed Principles. The specific meaning of the "well-being of all of the people" requirement is clearly indicated in the following portion of the requirement in Sen. Doc. 97:

> "Hardship and basic needs of particular groups within the general public shall be of concern, but care shall be taken to avoid resource use and development for the benefit of a few or the disadvantage of many. In particular, policy requirements and guides established by Congress and aimed at assuring that the use of natural resources, including water resources, safeguard the interests of all of our people shall be observed."

In explaining why he asked to have the current planning policy standards printed as a Senate Document, Senator Clinton P. Anderson of New Mexico gave particular emphasis to the "well-being of all the people" requirement by quoting the requirement in its entirety. More recently, the Flood Control Act of 1970 (Public Law 91–611) states: "It is the intent of Congress that . . . the well-being of the people of the United States . . . (is to be one of the) objectives to be included in federally financed water resource projects . . ." Since the current "well-being of all the people" requirement was not retained in the proposed standards, the railroads do not consider that these standards meet the intent of Congress.

The railroads believe special care must be taken to avoid resource use and development for the benefit of a few to the disadvantage of many and that this objective should be spelled out to help subdue the influence of special interests. The railroads, therefore, urge the Council to retain the current "well-being of all the people" requirement as presently worded in Senate Document No. 97. The railroads also suggest adding immediately before the "well-being" requirement, the following wording in Senate Document No. 97 of the basic objective in plan formulation:

> "The basic objective in the formulation of plans is to provide the best use or combination of uses of water and related land resources to meet all foreseeable short- and long-term needs."

2. *National Public Objectives for Navigation Projects*

The railroads are concerned that the specific goals of the national economic development objectives, which are now in effect, will no longer be spelled out in the proposed principles with the possibility that the narrow interests of the barge lines and waterway shippers may dominate in future evaluations.

The national public objective for navigation projects presented in the water resource evaluation procedures dated May 1950 and May 1958 was as follows:

> "From a public viewpoint, a navigation project will be considered economically desirable if it results in provision of *needed* transportation service at less total cost than that of equivalent service in the absence of the project." (Emphasis supplied.)

It is clear from this statement that navigation projects should not only be evaluated from an economic standpoint, but that they should be evaluated to determine if they would provide a transportation service which is required from the public viewpoint, and not merely from that of waterway carriers and shippers who seek improved facilities to enhance their profits.

The present standards in Senate Document No. 97 elaborate in somewhat greater detail the national public objectives for navigation projects. The specific statements are as follows:

> *Page 1:* "Water and related land resources and management are essential to economic development and growth, through (concurrent) provision for water navigation facilities which provide a needed transportation service with advantage to the Nation's transportation system."

> *Page 3:* "(Multiple-purpose) planning for the use and development of water and related land resources shall be on a fully comprehensive basis so as to consider—(1) The needs and possibilities for all significant resource uses and purposes of development, including, but not limited to—; navigation in relation to the Nation's transportation system;"

It is quite clear that the present standards require that navigation projects be planned and evaluated in relation to the Nation's transportation system. Furthermore, such projects shall meet the requirement of providing needed transportation with advantage to the Nation's transportation system.

These national public objectives for navigation projects in the current standards are sound and important objectives which should be retained in order to assist in providing the best use or combination of uses of our nation's resources. The railroads are concerned that these national public objectives for navigation projects have not been retained in the proposed standards. Unless the Council plans to abandon the national or comprehensive public viewpoint, the railroads urge the Council to retain for at least the national economic development objective the specific wording of the objectives for navigation and other projects given in Section II–A of the present standards (Sen. Doc. 97).

3. *Regional Development Objective*

The addition of the regional development objective in the Proposed Principles represents a substantial departure from the traditional single national economic development objective and is likely to result in making national benefit-cost calculations and comparisons of little, if any, value. Present cost-sharing policies make expenditures for water resource projects very attractive from the local or regional point of view, since they bear only a small part, if any, of project costs and reap much of the benefits. The railroads are concerned that the inclusion of secondary and regional benefits in project analysis will be used as an excuse to overcome the effect of higher interest rates.

The railroads share the views of many others that secondary and regional benefits induced by or stemming from water resource projects tend to be local in nature with offsetting disadvantages elsewhere in the economy. Evaluation of regional development benefits would in all likelihood involve double counting of benefits.

The policy in the proposed standards that the regional development objective is to be considered in plan formulation only "with advance approval" or "when directed" raises the following very important, but apparently unresolved, questions:

1. Which governmental group or groups shall have the authority to give approval for use of the regional development objective?
2. What is to be the criteria for obtaining approval for the use of the regional development objective in a particular planning activity?

In view of the possibility that the regional development objective may be abused, the railroads urge that the Council withhold the proposed standards from Presidential review until criteria for establishing the use of the regional development objective have been developed and made available to the public for comment.

Evaluation of Water Resource Projects

4. *Viewpoint for Economic Analysis*

The railroads are concerned that the omission from the Proposed Principles of language setting forth the broad "comprehensive public viewpoint" from which projects are to be evaluated may indicate that the effect of projects on railroads and other forms of transportation will not be given adequate consideration.

The viewpoint from which project effects are evaluated is of fundamental importance when attempting to provide the best use, or combination of uses, of the nation's water and related land resources. In the past, there has been general agreement that with Federal projects, a comprehensive public viewpoint should be taken as opposed to a limited point of view. The comprehensive public viewpoint was specified in the current planning policy document (Sen. Doc. No. 97), in the May 1950 and May 1958 evaluation procedures, and in the "Report of the Federal Civil Works Program as Administered by the Corps of Engineers," published as Part 1, Volume 3, of the 1951 Annual Report of the Chief of Engineers. The essentially similar wording presented in all instances was as follows:

> "A comprehensive public viewpoint shall be applied in the evaluation of project effects. Such a viewpoint includes consideration of all effects, beneficial and adverse, short range and long range, tangible and intangible, that may be expected to accrue to all persons and groups within the zone of influence of the proposed resource use or development."

The great extent to which the evaluation viewpoint can influence the measurement of navigation project effects is clearly shown from the following project estimates given in Volume 5 of the Pittsburgh District Engineer's report of January 1965 on the proposed 120-mile, one-billion-dollar Lake Erie–Ohio River Canal project:

	Estimated Average Annual Values	
Project Evaluation Viewpoint	*Barge Traffic, Tons*	*Transportation Savings*
Waterway Shippers Only	94,330,000	$138,100,000
Comprehensive Public	5,890,000	$ 10,100,000

In view of the importance of the comprehensive public viewpoint when establishing both project needs and effects, the railroads urge that a similar wording of this viewpoint requirement for economic analysis of water resource projects be carried over into the Proposed Principles.

5. *Evaluation of Navigation Project Effects*

The railroads find serious deficiencies in the proposed standards regarding the measurement concepts and procedures for evaluating navigation project effects under the national economic development objective. The principal deficiency is that little or no attempt has been made to evaluate the benefits for this objective from the comprehensive public viewpoint. From such a viewpoint, for example, the national economic development benefits due to the increased output of the nation's goods and services should be the increased value "to the nation" rather than "to the users." As has been shown in Section 4 of this statement, the net benefits of a project from the comprehensive public viewpoint may be only a fraction of the primary direct benefits to the users.

The lumping together of all national economic development benefits for navigation and other water resource projects under the single heading of "Measurement of the Value to Users of Increased Outputs" leaves much to be desired. As indicated above, from the national or comprehensive public viewpoint the measurement should be the value "to the nation" of increased outputs. Secondly, for navigation projects there is usually no increase in the nation's total output of transportation service since nearly all of the waterway traffic would move in the absence of the project. Thirdly, and as will be discussed in the next section, there is no consideration of standards for measuring improvements in national economic efficiency.

While the standards indicate "Plans for the provision of transportation through inland waterways and harbors are established to complement or extend the overall national transportation system . . .", to the extent that nearly all of the inland waterway traffic would move in the absence of the project it is more correct to indicate inland waterway facilities primarily replace or serve as a substitute for existing transportation facilities. This is particularly significant since the railroad industry transportation facilities are considerably underutilized. The standards also indicate navigation projects are established to achieve "an improved movement of goods" and that the beneficial effects are related "to the improvements in the transportation services provided." The standards fail to indicate what these improvements consist of. They neither state nor imply that any improvements are obtained with respect to the speed of the movement, the quality of the movement, or the total cost of the goods and services (i.e., resources) necessary to provide the movement.

The following statement on page 24156 of the standards is completely inadequate: "the beneficial effects . . . are measured as: The savings in the movement of commodities on the waterway when compared with movement via existing modes:" This statement fails to indicate savings in what and to whom. The key words which are obviously (and probably intentionally) omitted are "the cost of providing" which should follow the words "the savings in." Prior standards (including the present standards in Sen. Doc. 97 and the May 1950 and May 1958 standards) *plus* the Council's Special Task Force report of June 1969 on "Procedures for Evaluation of Water and Related Land Resource Projects" clearly state that, for commodities which would move in the absence of the project, the (net) benefit (from the national public viewpoint) is (equal to and can be) measured by the "saving as a result of the project in the cost of providing the transportation service." This wording should be retained.

The procedure (hereinafter referred to as method No. 1) for measuring the net project benefits to the nation directly (without determining which groups are affected and to what extent) has been called the "cost of providing the service" procedure. It is based on a comparison of the relative efficiency of the various modes of transportation and requires a determination of the incremental (or avoidable) cost required to provide the transportation service. This procedure has consistently been prescribed beginning with the May 1950 standards. Its first and only use, however, was on a limited experimental basis in 1964 at which time it was officially rejected by the planning agency for navigation projects. The excuse given by the Chief of Engineers (in his multiple letter ENGCW–PE dated November 20, 1964) was lack of the "availability of acceptable (cost) data for consistent application" of this procedure. While it may be true that incremental transportation cost data are not always readily available, some claim it was the adverse project evaluation results from the use of this procedure which were primarily considered unacceptable. In resource terms the validity of the comparative cost principle is clear. The significant disadvantage of this procedure is that it fails to establish the magnitude of the primary direct benefits to the identifiable beneficiaries. It likewise does not determine the direct adverse effects to adversely affected groups.

Theoretically the "cost of providing the service" procedure (method No. 1) does not conform to the comprehensive public viewpoint requirement for the evaluation of project effects since it does not "include consideration (i.e., a determination) of *all* effects . . . that may be expected to accrue to *all* persons and groups within the zone of influence of the proposed resource use or development." The alternative to benefit evaluation method No. 1 is a method (hereinafter referred to as method No. 2) which evaluates all effects to all persons or groups. Evaluation method No. 2 can be defined or stated as follows (see page 273 in Part 1, Volume 3 of the 1951 Annual Report of the Chief of Engineers):

> "The economics of such (transportation) service (that is the product of navigation improvements) *must* be determined from a *comprehensive public viewpoint* which includes consideration of *all effects*, beneficial *or adverse*, short range or long range, that can be expected to be felt by *all persons or groups* in the entire range of influence of the project." (Underlining and words in brackets have been added to provide emphasis and clarify the context of the statement respectively.)

With this method, the effect of the project on each group which is directly affected is determined separately. The sum of the beneficial effects gives the national economic development benefit. This is balanced against the sum of the adverse effects, which in the proposed standards would be displayed separately. With method No. 2 no attempt is made to evaluate the secondary or induced effects to producers or consumers of the prospective waterway traffic; to those shippers, without access to Federally-financed inland waterways, that compete with the prospective waterway shippers; or to other shippers which would continue to rely on the present transportation carriers and may be faced with rate increases intended to recover that portion of the carrier's fixed costs which had previously been covered by the traffic diverted to the waterway.

With method No. 2, the benefits to the waterway shippers are the savings in freight rates as indicated in section d (2) on page 24156 of the standards. The waterway carriers benefit from an increase in net income on new traffic which the waterway provides, and the existing carriers experience an adverse effect due to a loss of net income on traffic diverted to the waterway. The net gain or loss in income to each mode is the difference between the cost of providing the transportation service and the rate charged for the service. The net benefits of the project with method No. 2 are essentially the same as with method No. 1, *provided* the effects to *all* the directly-affected groups are evaluated.

While method No. 2, or an incomplete adaptation thereof, is the traditional procedure, and is presented in the proposed standards, for evaluating navigation project effects, little effort (notably none in the proposed standards) has been made to date to evaluate the direct project effects to any of the directly-affected groups other than the prospective waterway shippers. In the case of the direct benefits to the waterway carriers, there has previously been justification for not attempting to evaluate these benefits separately. Since most of the prospective waterway traffic would probably move on the waterway by contract or industry-owned carriers for which there are no published rates, it was common practice by the planning agency to use a constructed barge rate based on an estimate of barge costs for the purpose of estimating the savings in freight rates to the waterway shippers. With this procedure the benefits to the waterway carrier are included in the estimated benefits to the shippers. For those waterway shippers which own and operate tow boats and barges, their benefits are, in fact, the difference between their cost of providing the barge service and the rate which they would have to pay for movement by alternate modes. In contrast to this logical and acceptable explanation as to why little or no effort has been made to evaluate benefits to the waterway carriers, the reason which has been given by the planning agency for omitting consideration of the loss of income to existing carriers, from which traffic would be diverted to the waterway, needs to be re-examined.

The explanation given for the failure to evaluate the loss of income to competing land carriers is as follows (see page 299, Part 1, Vol. 3 of the 1951 Annual Report of the Chief of Engineers):

> "The apparent loss of traffic by existing carriers from diversion of traffic to a waterway is not applied as a reduction of benefit. The Corps of Engineers considers that there is an overall economic gain to the nation when transportation is made available to the public at lower cost and that, as has happened in most such cases, benefits to overland carriers from feeder and transfer traffic developing as a result of the waterway will in the long run offset losses by overland carriers of shipments suited to water movement."

This statement contains two false premises. The logic of omitting, in an economic evaluation of a project, the adverse effects because it has already been decided in advance that the project provides an overall economic gain to the nation is absurd. Also, it is the experience of the railroads, for example those serving the upper Mississippi River region, that rail traffic generated as a result of a waterway is very minute. The railroads suggest that possibly the real reason for the failure to evaluate the adverse effect of the project to existing carriers is that there would, in fact, be no net gain to the nation. Also, justifying the omission of adverse effects to existing carriers on the basis of the claim "that one should confine the evaluation of project effects to the comprehensive public and not to any particular group" does not stand up because, with method No. 2, the net benefits from the comprehensive public viewpoint *can only be obtained* by considering *all the effects,* beneficial and adverse, *to all groups* that are directly affected.

While evaluation method No. 1 is required for implementation type studies in the current standards, an added reason for specifying method No. 2 in the proposed standards is the fact that Congress in Section 7 (a) of the Department of Transportation Act of 1966 (Public Law 89–753) has defined (and established the procedure to be followed in determining) the "primary direct navigation benefits" to "shippers using the waterway." Since this procedure applies specifically to the situation (covered in heading d (2) on page 24156) where traffic will move in the absence of the waterway improvement, and since the procedures presented in section d (2) are precisely those specified by Congress in Section 7 (a), it would appear appropriate to omit heading d (4) and insert the direct quote from Section 7 (a) under heading d (2).

The principal deficiency of the procedures in the proposed standards for evaluating navigation project effects is that they omit consideration of the effect of navigation projects on any group other than the waterway shippers. The railroads do not interpret Section 7 (a) of the DOT Act as prohibiting the determination of beneficial or adverse effects to other groups. It is clear from the Congressional hearings on the bills to create the Department of Transportation that Congress specified in Section 7 (a) the "current rate" procedure for calculating the direct benefits to waterway shippers because of objections from waterway interests to the "projected" or "water-compelled" rate procedure promulgated by the Chief of Engineers on November 20, 1964. At no point in the hearings or Committee reports on the DOT Act was there any discussion or mention of evaluating navigation project effects exclusively from the viewpoint of the waterway shippers. The unresolved issue at the time was solely whether current rates or projected rates should be used for estimating the direct benefits of a navigation project to the waterway shippers.

Unless the Council intends to completely abandon the comprehensive public viewpoint in water resources planning and evaluation, the railroads urge the Council to include in the national economic development account the direct benefits of navigation projects to waterway carriers due to increased income and, likewise, include as an adverse effect the loss of income by transportation modes from which traffic is diverted. The gain or loss in income is the difference between the cost of providing the transportation service and the rate charged for the service. Both the May 1950 and May 1958 water resource evaluation standards required, when using method No. 2, that the navigation project benefits "be adjusted for any reduction in net income by transportation services from which traffic is diverted." This requirement should be carried forward in the new procedures.

6. *Improvements in National Economic Efficiency*

The proposed principles and standards state (on pages 24145, 46, 51, and 53 of the Federal Register for December 21, 1971) that the national economic development beneficial effects consist of the following:

1. Increases in the value of the nation's output of goods and services.
2. Improvements in national economic efficiency.

The railroads take no exception to this breakdown of the national economic development benefits; however, they find no measurement standards have been provided for improvements in national economic efficiency.

This inadequacy begins with the following statements under "General Measurement Concepts" on page 24153:

"For convenience of measurement and analysis, beneficial effects of national economic development are classified as follows:

a. The value to users of increased outputs of goods and services from a plan; and

b. The value of output resulting from external economics caused by a plan."

It is immediately obvious that there is no reference whatsoever to improvements in national economic efficiency in this classification for measurement and analysis of beneficial effects for the national economic development objectives. Furthermore, in the subsequent development of benefit measurement procedures for this objective we find no specific mention whatsoever regarding evaluation of "improvements in national economic efficiency."

It is important for the Council to establish procedures for the direct measurement of benefits due to improvements in national economic efficiency for at least those water resource uses (hydroelectric power and commercial navigation) where there are alternatives in the private sector and where water resource development decisions should be based primarily on a comparison of the relative efficiency (resource costs) of alternatives. Consequently, the railroads recommend that the standards present and specify the use of evaluation method No. 1 rather than method No. 2 for this specific purpose. (See section 5 for explanation of evaluation methods.) Method No. 1 would therefore be presented as the procedure to be used to directly measure the improvement in national economic efficiency with respect to existing or alternative transportation facilities and service.

In the normal and logical sequence of Framework studies and assessment, followed by regional or river basin studies, followed in turn by implementation studies of particular projects, the railroads suggest that navigation project evaluation method No. 1 be used almost exclusively until the implementation studies. At that time evaluation method No. 2 would be used to establish the project feasibility. Method No. 1 would be used for the initial appraisal of the suitability of navigation projects versus various alternatives for meeting the basic needs for transportation in the study area. This would be accomplished in the Framework studies and assessments. As the planning process progressively zeros in on the selection of a specific project for a detailed feasibility study, the shift would be from method No. 1 evaluation to method No. 2 evaluation. By the time an implementation (i.e., single project feasibility) study is undertaken, prior studies will, presumably, have looked at and rejected other alternatives. Ideally, the required consideration of alternatives in implementation studies will largely have been accomplished in prior studies.

Special Transportation Considerations

7. *Need for Overall Transportation Studies*

In order to determine if a proposed navigation project will meet the requirement in the current planning policy standards that it "provide a needed transportation service with advantage to the nation's transportation system," the railroads consider it imperative that the planning agency or commission have access to certain information on the total transportation system in the study area. The specific information needed to make this determination is essentially the following which section 7 (b) of Public Law 89–670 (the D.O.T. Act) requires the Secretary of Transportation to furnish for various other transportation investment proposals:

> "project growth of transportation needs and traffic in the affected area, the relative efficiency of various modes of transport, the available transportation services in the area, and the general effect of the proposed investment on existing modes and on the regional and national economy."

The railroads urge the Council to require the same information be furnished by the Secretary of Transportation for all water resources planning and assessment studies involving navigation project proposals. Also, without a study of the total transportation system, it is almost impossible to develop and evaluate alternatives for meeting the future transportation needs in the study area.

The railroads are not aware that any progress has been made toward implementing the following sound recommendation given on page 1–15 of the Council's first National Assessment report (of November 1968) on the nation's water resources:

> "The Council recognizes the need for a broadly based, long-range study of the inland navigation system, including the Great Lakes and intracoastal waterways. Such a study would consider the system as it relates to regional and national requirements and other multiple-purpose uses, including recreation boating."

In his March 11, 1969, address (at the AREA 68th Annual Convention) on "National Water Resources Planning," the then Executive Director of the Water Resources Council, Mr. Henry P. Caulfield, Jr., referred to the Council's recommendation that really there ought to be a national transportation study, in which navigation is put with other modes in a comprehensive national study to look at the question of the relative economics of the various modes. Mr. Caulfield indicated the Council had not taken a position as to exactly how such a long-range study of the inland navigation system would be conducted, but that the "old Council" (under President Johnson) took the position this study should be undertaken within the framework of a national transportation system. The possibility that such a study might be conducted under the leadership of the Department of Transportation was also mentioned.

Mr. Caulfield indicated the Council recognizes the fact that the study of the projected needs for navigation in the comprehensive river basin studies is not being determined with relation to a national transportation study and gave the following reasons why this is so:

(a) In making national assessment and comprehensive river basin studies, the use of water resources for the purpose of navigation is being related (solely) to the use and development of water resources for other purposes such as flood control or hydroelectric power, or recreation or fish and wildlife.

(b) What is really being planned in water and related land resources planning is public activity (solely) because all the purposes for the use of water and related land resources are, by and large, public functions of the Federal Government, state governments and local governments.

This explanation for the limited approach being taken in determining the future navigation needs fails to justify the approach. Also, these restrictions have not been present in the studies of the projected needs for hydroelectrical power in the comprehensive river basin planning studies. Comprehensive studies are being made by the Federal Power Commission of all the electric power requirements and existing production in the river basin regions to assist in establishing the need for future hydroelectrical power developments. The planning of the use of our nation's water resources for commercial navigation should involve the same considerations as does the planning for the use of these resources for hydroelectric power. In each case there are specific needs to be met, there are alternative facilities in the private sector for meeting these needs, and the capacity of the total facilities should be related to the actual requirements. Also, the development of additional facilities in each case should be based primarily on the comparison of the relative efficiency of the various alternatives for meeting the future requirements.

The railroads strongly object to the Council's continued reluctance to obtain the information required to determine in water resources planning studies the future needs for commercial navigation with reference to the nation's total transportation system. These artificial and unnecessary restrictions, which the Council has imposed on the navigation studies for water and related land resources planning, are unacceptable to the railroads.

8. *Department of Transportation Participation*

When the legislation establishing the Department of Transportation was originally considered, the standards and criteria for economic evaluation of the transportation features of multi-purpose water resource projects were to be developed by the Secretary of Transportation after consultation with the Water Resources Council. These standards and criteria were also to be compatible with those for economic evaluation of the nontransportation features of water resource projects. This section was subsequently amended such that the authority of the Water Resources Council to establish standards and criteria for the evaluation of water resource projects, including the navigation features, established by section 101 of Public Law 89–80 (the Water Resources Planning Act) would be unchanged. At the same time Congress expanded the Water Resources Council "to include the Secretary of Transportation *on matters pertaining to navigation features* of water resource projects." (emphasis supplied.)

The reference on page 24151 of the proposed standards to this provision of the DOT Act omitted the important fact that the Secretary of Transportation's participation on the Council is to be specifically with reference to "matters pertaining to navigation features." The railroads suggest the wording of this reference be modified as follows:

> "The Department of Transportation Act of 1966 (Public Law 89–670) provides standards for evaluating the primary direct benefits of navigation projects to waterway shippers and expanded the Water Resources Council to include the Secretary of Transportation on matters pertaining to navigation features of water resource projects."

The words "the primary direct benefits of" and "to waterway shippers" have also been added to the suggested reference wording in order to clearly indicate the exact extent to which the evaluation standards have been spelled out by Congress.

Since the DOT Act did not indicate the Secretary of Transportation was to be involved in only certain matters pertaining to navigation features, Congress appears to have given the Secretary the opportunity to participate in all matters pertaining to the navigation features of water resource projects. From the hearings on the legislation which established the DOT, it is quite clear that a primary reason for including the Secretary of Transportation as a member of the Council was to assure that the Secretary would participate in establishing standards and criteria for the transportation features of water resource projects. It appears the Secretary did not have this opportunity. Senator William Proxmire, in his introduction of S.4338, on September 14, 1970, stated: "no one from the Department of Transportation was on the (Water Resources Council's special) task force which developed the new guidelines." The railroads share Senator Proxmire's concern regarding the failure of the Council to provide the Secretary of Transportation the opportunity to participate in the establishment of standards and criteria for evaluating the transportation features of water resource projects.

The railroads urge the Council to provide the opportunity for the Department of Transportation to participate to a much greater degree in both the establishment of evaluation standards and in the development of information needed to obtain sound planning of our nation's water and related land resources. The specific information needed is the following (which Congress, in Public Law 89–670, requires the DOT Secretary to furnish for other transportation investment proposals):

(a) "Projected growth of transportation needs and traffic in the affected area.
(b) "The relative efficiency of various modes of transport.
(c) "The available transportation services in the area.
(d) "The general effect of the proposed investment on existing modes and on the regional and national economy."

Since the Corps of Engineers has the overall responsibility for planning and developing the navigation features of water resource planning studies, the following official reaction of the Corps to the development of this type of information by the DOT is important:

> "Section 7 (as originally drafted) would also enable the Department of Transportation to provide the Corps of Engineers with information, such as projections of transportation needs, for use in its studies of prospective navigation projects. This is consistent with, and is a desirable enlargement on, the present arrangements the Corps of Engineers has with the Office of the Under Secretary for Transportation in the Department of Commerce.
>
> "The fiscal year 1967 civil works budget includes $187,000 for funding data collection and analysis activities to be performed for the Army by that office, and this function would be transferred to the new Department by S.3010.
>
> "We believe it is logical that a Department of Transportation should be the focal point for developing traffic projections and other economic background data relevant to navigation and other Federal transportation projects, and the Corps of Engineers would, of course, welcome the assistance of the new Department in this regard."

(From the Statement of Maj. Gen. R. G. MacDonnell, Acting Chief of Engineers, at the March 29 and 30, 1966, hearings on the proposed DOT Act before the Committee on Government Operations, United States Senate.)

In the process of discharging its responsibility for developing proposed evaluation standards and supervising the planning of our nation's water and related land resources, the railroads believe the Council has not given adequate consideration to the fact that navigation project proposals need to be formulated, evaluated, and reviewed, not only as a water resource project by a water resource planning agency, but also as a potential segment of our nation's transportation system by the Department of Transportation. Each of two sets of alternatives must be evaluated when considering proposals to use water resources for commercial navigation. One set consists of alternative uses (or non-use) of these resources, and the other set consists of alternative transportation facilities. The railroads recommend that the Council assign to the Secretary of Transportation the responsibility for formulating and evaluating the transportation alternatives for commercial navigation project proposals at each step in the planning process.

Other Aspects of the Proposed Standards

9. *Discount Rate*

The railroads support the Council's position that the discount rate for evaluating water resource projects should take account of the "opportunity cost" as determined by the current and prospective cost of capital on private investments. The railroads, therefore, support as the first step in obtaining this objective, the Council's proposal to adopt a 7 percent discount rate for evaluating water resource projects during the next five years.

The discount rate which has been used in the past in evaluating the costs and benefits of water resource projects has been criticized as being unrealistically low. While this rate has been increased considerably in recent years, the current discount rate of 5⅝ percent is still too low in terms of the opportunity cost of capital. Consequently, current policy provides a built-in bias which results in understating project costs, favors public versus private undertakings, and precludes efficient use of the nation's resources. The railroads concur with the Council that use of the opportunity cost rate in evaluating Federal investments is necessary to achieve equity from the standpoint of the Federal taxpayer who must finance Federal investments. The analysis of discount rate in Section IV–D of the proposed standards is valid and well presented.

While the railroads recognize the preferences of the Federal political process regarding the desire to transfer income to people in specific economically-depressed regions by subsidizing water resource projects, the railroads question the use of a low interest rate to implement such subsidies. The railroads concur with the Council's position that the use of a low interest rate is often an insufficient instrument for this purpose because it biases the design of these projects toward those with higher near-term costs and lower near-term benefits. While a subsidy to particular depressed areas may be desirable, an indirect approach by providing benefits to water transportation at the expense of railroad transportation may only have the effect of transferring a financial crisis from one economic segment and locale to another.

The railroads seriously question the justification and soundness of continuing the policy of subsidizing navigation features of water resource projects with the resultant transfer of already low income from railroads. Also, the diversion of traffic from railroads to subsidized waterways further aggravates the railroads' problems of excess capacity and low earnings, while at the same time the services provided by railroads meet essential national needs.

10. *Cost-sharing and Reimbursement*

The railroads endorse the following cost-sharing and reimbursement policy objective presented in the proposed standards:

> "Reimbursement and cost-sharing policies shall be directed generally to the end that identifiable beneficiaries bear an equitable share of cost commensurate with beneficial effects received in full cognizance of the multi-objectives."

The railroads also feel the following additional statement in the proposed standards is a step toward a more equitable balance in transportation expenditures:

> "Since existing cost-sharing policies are not entirely consistent with the multi-objective approach to planning water and related land resources, these policies will be reviewed and needed changes will be recommended."

The need for determining the direct benefits to the barge operators was indicated in section 5. A determination of these benefits could also be helpful in the consideration of reimbursement and cost-sharing policies.

The practice of subsidizing waterway carriers and shippers is economically unsound and unfair to the nation's general taxpayers who pay for the construction, operation, and maintenance of navigation projects. The Government has yet to implement any attempt to recover from the waterway users any part of the huge annual expenditures for commercial navigation projects. Consequently, such costs are never reflected in barge rates and this fact results in the diversion of traffic from existing modes, particularly the railroads, whose rates of necessity cover the complete cost of constructing, maintaining, and paying taxes on their right-of-way, track and structures. Subsidized waterway projects not only encourage the wasteful use of water and related land resources, but they create excess total transportation capacity of limited usefulness while they jeopardize the more general transportation functions provided by the railroads.

The adoption of adequate waterway user charges would shift the cost of navigation projects from the general taxpayers to waterway carriers and shippers as direct beneficiaries of such projects for private gain. Since much of the pressure for federally-financed navigation projects is generated by special interest groups who benefit from federally provided facilities, an adequate user charge would reduce pressures for uneconomic projects. Adequate user charges would also discourage the overdesign and early replacement of waterway projects, would encourage transportation by the most efficient mode in basic economic terms, and would be consistent with and encourage sound national transportation objectives.

11. *Miscellaneous Aspects*

In addition to the preceding comments on specific key sections of the proposed standards, the railroads submit the following additional comments on various aspects:

The railroads concur with the Council's decision not to include from the July 1970 Task Force Report those benefits in the national economic development account from the use of underemployed or unemployed resources as the result of:

1. "the use of intermediate goods and services resulting from the plan;" or
2. "expansion of output by firms who are indirectly affected by the installation of the project or indirectly affected by consumers and firms who use final and intermediate goods, respectively."

Benefits of this type are too conjectural and, furthermore, they are erroneously assumed to be uniquely associated with projects of the kind here under consideration.

With reference to the schedules established for applying the proposed standards, the railroads take the position that all presently authorized projects on which actual construction has not commenced should be reviewed in accordance with the proposed principles and standards.

Under section d(2) on page 24156, the railroads strongly object to the use of the word "cost" in the following statement:

> "Moreover, as a practical matter, it will be deemed realistic to assume a sharing of the total traffic movement among alternative modes rather than to assume complete diversion to the lower cost mode."

It is clear that what is meant is cost to the shipper or in other words, the freight rate or charges. It is, therefore, suggested this statement end with the words "complete diversion to the mode with the lower freight charges." Likewise in the several instances where the word "cost" is used in section d(3) on page 24156, it would appear more appropriate to use "rate" or "charges."

With reference to the traffic studies referred to in section (2) on page 24156, the railroads urge the Council to require that these studies be open to the public at all stages.

Summary

12. *Summary of Recommendations*

A summary listing of the recommendations by the railroad industry in general is as follows:

Regarding Water Resource Planning Objectives:

1. That the "well-being of all the people" requirement of the current standards (Senate Document 97, 87th Congress) be retained in the proposed standards as a safeguard against favoring limited and special interests.

2. That the wording of the national public objective requirements for navigation and other projects on pages 1 and 3 in the current standards be retained.

3. That the proposed standards be withheld from Presidential review until criteria for establishing the use of the regional development objective for project planning have been developed and made available to the public for comment.

4. That regional economic development plans should be prepared by other than water planners and include, as an integral and necessary part of such plans, the development of water and related land resources.

Regarding Evaluation of Water Resource Projects:

5. That the requirement (on pages 5 and 6 in the present standards) that a comprehensive public viewpoint shall be applied in the evaluation of project effects be retained.

6. That the standards for measuring beneficial effects of national economic development be rewritten so as to (a) evaluate benefits from the national (i.e., comprehensive) public viewpoint, (b) avoid lumping together all such benefits under the heading "Measurement of the Value to Users of Increased Outputs", and (c) include standards for measuring improvements in national economic efficiency.

7. That the specific improvement (or improvements) in the movement of goods which navigation projects are established to achieve be indicated.

8. That the beneficial effects of navigation projects for the national economic development objective be defined (as in prior standards) as the "savings in the cost of providing the transportation service."

9. That the standards for measurement of the net beneficial effects of navigation projects include both the direct procedure of comparing the cost of resources required to provide the service and the indirect procedure of evaluating and displaying separately both the beneficial and adverse effects to those groups (shippers and transportation carriers) directly affected by the project.

10. That the procedure of separately determining the direct project effects to all the directly affected groups be specified for evaluating navigation improvements in implementation studies.

11. That the direct benefits of navigation projects to shippers be defined and evaluated in accordance with the standards provided by Congress in section 7(a) of the Department of Transportation Act of 1966.

12. That the direct beneficial (or adverse) effects of navigation projects to the directly affected transportation carriers represent the losses to existing carriers as well as the prospective gains to carriers on the waterway.

13. That the direct procedure of comparing the incremental (or avoidable) cost of resources required to provide equivalent transportation services be specified in Framework studies and assessments plus regional or river basin studies for the purpose of determining the relative efficiency of alternative means of meeting the overall transportation needs in the nation or area under study

14. That in the following statement on page 24156 of the standards, the words "lower cost mode" be replaced by "mode with the lower freight charges":

> "Moreover, as a practical matter, it will be deemed realistic to assume a sharing of the total traffic movement among alternative modes rather than to assume complete diversion to the lower cost mode."

Also, that "rate" or "charges" be used in place of "cost" where reference is made on page 24156 to what shippers would have to pay for transportation service.

15. That the traffic studies referred to on page 24156 be open to the public at all times.

16. That the standards specify no navigation features shall be incorporated in a water resource project unless the net national economic development benefits of the navigation features are sufficient to cover the direct costs of the navigation features plus a reasonable share of the costs which are common to the entire project.

Regarding Special Transportation Considerations:

17. That the reference to the DOT Act on page 24151 of the standards be reworded as follows:

> "The Department of Transportation Act of 1966 (Public Law 89–670) provides standards for evaluating the primary direct benefits of navigation projects to waterway shippers and expanded the Water Resources Council to include the Secretary of Transportation on matters pertaining to navigation features of water resource projects."

18. That the Department of Transportation participate to a much greater degree in all of the Council's functions pertaining to navigation features of water resource projects including the establishment of evaluation standards.

19. That adequate consideration be given to the fact that navigation project proposals be evaluated not only as a water resource project by a water resource planning agency, but also as a potential segment of our nation's transportation system by the Department of Transportation.

20. That development of the following information (which Public Law 89–670 requires the Secretary of Transportation furnish for evaluating certain transportation investment proposals) by the Secretary of Transportation be required for all water resources planning and assessment studies involving navigation project proposals:

> "projected growth of transportation needs and traffic in the affected area, the relative efficiency of various modes of transport, the available transpor-

tation services in the area, and the general effect of the proposed investment on existing modes and on the regional and national economy."

21. That evaluation of projected needs for navigation in water resources planning and assessment studies be determined with relation to the total transportation system in the nation or study area.

22. That for formulation studies the Secretary of Transportation be directed to furnish (to that agency responsible for planning the navigation features of water resource projects) an evaluation regarding the extent to which navigation proposals would provide a needed transportation service with respect to the nation's transportation system. Also, that the Secretary develop and make a comparison evaluation of those alternatives which he believes need to be considered for meeting the future transportation needs in the study area.

Regarding Other Aspects of the Proposed Standards:

23. That the discount rate for evaluating water resource projects take into account the opportunity cost as determined by the current and prospective cost of capital on private investments.

24. That the proposal to use a 7 percent discount rate for evaluating water resource projects during the next five years be implemented.

25. That the sound cost-sharing and reimbursement policy objective in the proposed standards be adopted.

26. That the existing cost-sharing policies including the proposals for waterway user charges, which have consistently been recommended by previous Administrations, be reviewed and needed changes recommended.

The following draft of proposed Part 1 of Chapter 25 of the Manual is presented as information. Comments and criticism are invited.

Part 1

Project Planning

1.1 PUBLIC PROJECTS

1.1.1 PURPOSE AND TYPES OF PROJECTS

Civil works projects may be for the purposes of flood control, navigation improvements, land reclamation, industrial water supply, recreation, hydroelectric power generation, irrigation or pollution control, singly or in combination. Development of industrial sites may be included in this type of work.

These ends may be effected by levees, dikes, dams or other works to confine the water within limits, by dredging or other construction to improve the hydraulic characteristics of the channel, by land fill, by new drainage systems with or without pumping, by imposing the legal effect of zoning, or by other means.

1.1.2 PHYSICAL EFFECT OF PROJECT ON RAILROAD

Existing tracks and facilities may be changed in line or grade; bridges frequently must be raised, extended, or spans lengthened; fixed spans may be replaced with draw spans; and dikes with flood gates may be constructed across existing lines or embankments taken into a diking system. Changes in pool level may affect bank stability. Existing drainage and subdrainage schemes may be changed or completely revised. Whenever water level or water table is altered, possibility of effect of subgrade and on foundations should be considered. Change in velocity of tributary channels may alter the previous rate of sedimentation.

1.1.3 ECONOMIC EFFECT OF PROJECT ON RAILROAD

1.1.3.1 Effect on Traffic

The intentional effects, such as provision of facilities for competitive or supplementary transportation modes are usually obvious. Less obvious are some of the indirect or unintentional effects, such as restriction or enhancement of the operating efficiency of the carrier, provision or elimination of industrial customers, etc.

1.1.3.2 Appreciation or Depreciation of Railroad Property

Consider the effect on both operating and non-operating property. The effect of changing parcels between these two classifications should be considered. In the long range, the value of land will inevitably increase; judicious rearrangement of facilities frequently will release operating property to a more remunerative purpose.

1.1.4 PLANNING PARTICIPATION OPPORTUNITIES

1.1.4.1 Long-Range Comprehensive Basin Planning

The planning period for most such projects is long, frequently extending to a year or more. During this period, whether called upon for relevant information or not, the railroads frequently have information available which will be useful to the planning group, or which for their own interests should be presented to the planning group. Discussion during planning stage is commonly more beneficial to all concerned than at a later period after planning has progressed to design stages.

Many factors involved beside transportation, such as hydro power, flood control, recreation, etc., will mutually conflict. The final decision will generally be political and made by a branch of government. Prior to the imposition of this decision, it is incumbent on the engineer to present his position with utmost effectiveness.

1.1.4.2 Project Surveys

Project surveys should be to the end that a decision as to economic desirability, or otherwise, of the project may be well founded. Additionally they may include reports of social, ecologic and other aspects. Much of this is without the scope of engineering, yet may require engineering data for completion. Extensive topographic and hydrographic surveys are usually necessary. For most projects of the type covered in this Chapter, topographic surveys are best conducted by aerial methods, with ground parties used only for basic control and, if necessary, for minor detail. Except for projects of the smallest scope, hydrographic surveys should be made by organizations with considerable experience in this field and with the requisite specialized equipment.

Hydraulic studies involving any length of channel with varying flow rates, tidal harbors, or similar situations, can best be studied by hydraulic model.

1.1.4.3 Report Studies

Reports of proposed public projects should be critically reviewed by all affected parties. Particular attention should be given to all economic assumptions, data, derivations and conclusions; and to social and ecologic and other non-technical sections insofar as they may be based on insufficient engineering data.

1.1.5 ECONOMIC ANALYSIS

1.1.5.1 Benefits and Costs

The economic analysis must consider all effects of a proposed project, whether beneficial or adverse, public or private, and the most efficient use of all methods of transportation. Some of the steps necessary in making of economic studies and analyses are a) definition of alternative, b) determination of differences in result of various alternatives, c) expression of differences (money), d) justification of proposed investment, e) choice of alternative in other than monetary terms. A choice other than type most economic may be justified. The economic balance sheet would include the first investment costs plus maintenance and operation. Funds may be restricted and will have to be expended principally where the highest degree of effectiveness will be achieved.

1.1.5.2 Federal Agency Policies and Procedures

Section in preparation.

1.2 MARINE AND RIVER TERMINALS

1.2.1 PURPOSE OF PROJECT

Facilities are classified by the intended use, as grain, coal, ore, bulk liquid, container or general cargo terminals, ferry landing bridges, or other. If two or more types of service are to be maintained at one terminal, exercise care to avoid conflict between the several uses. Separated ships' berthing is frequently preferable.

An early determination must be made whether the terminal will be operated exclusively by a single user, e.g., the berth serving an oil refinery, or as a common user facility as with many general cargo berths in the U.S. In the former case, planning and criteria will generally be supplied by the potential user.

Industrial and commercial activities will need critical analysis, for many are not bound to port areas. A shipyard, for instance, would be expected to disturb or break the coherency of a port, and yet may be a necessary adjunct. Population centers, recreational, industrial and commercial interests compete for waterfront properties.

1.2.2 PLANNING CRITERIA

The purpose of the port or marine terminal is most efficiently to effect the transfer of cargo between different means of transport, with their differing time rates of flow, and with due regard to the economy of the total transportation scheme. To be considered are the economics of cargo accumulation, of handling cargo to and from the storage or concentration point, whether as export or import, and the duration of storage for all or any part of a lot.

Planning criteria delineate the general features of the project, may determine stages of construction, and should point toward several alternate types of construction later to be compared during the design phase (q.v.). Planning criteria are subsequent to estimates or assumptions of traffic character and volume, and must develop individually for each project, with the following as a guide: The existence of old facilities should not normally be allowed to control the location of a port. To fit new structures around old will probably not produce the best design. Heavy industry will present problems in the handling of large, heavy shipments. A solution may be ro/ro or floating cranes. The location of ports in the past has been based largely on the use of suitable natural topography. Increasingly the use of less desirable sites will be necessary, requiring reclamation of land by dredging and filling.

Planning for the marine phase may consider the navigational characteristics of the harbor and its approaches, either as is or as may be developed, the size and characteristics of shipping desired or available, and weather conditions. Requirements for ship repair facilities, pilotage and other services may also be considered. Planning for the cargo transfer phase will be governed by the type of material to be handled and will be affected by the characteristics of marine and land transportation; by the required rate of production, weather, storage facilities and area, and the degree of development of the working area. Many types of machinery are available, and some are adaptable to more than one type of cargo. The entire transfer from land vehicle to ship or barge and vice versa must be considered and overall cost per cargo unit minimized, within the adopted stipulations of ship time, availability of cars, etc.

Criteria for consideration of any of the modern, very heavy container handling—or similar—machines must include a careful review of the effect on construction costs of the very heavy wheel loads, whether on a structure or on paved area. Technical literature of the equipment manufacturers is not always complete and straightforward; all loading data must be carefully verified.

1.2.3 COLLABORATION WITH OTHER INDUSTRY OR GOVERNMENT

Planning of nearly any form of marine terminal will offer possible areas of cooperation between various industries and levels of government. This may take the form of technical assistance, aid in development of business, exchange of land areas, proposed operating agreements, and others. Joint use facilities are a management problem. Consideration should always be given to formation of a single operating organization.

1.3 REGULATION

1.3.1 FEDERAL (U.S.)

Regulation of these facilities is generally in the fields of safety (e.g. OSHA, FRA, CAA, U.S. Coast Guard Regulations); of taxation (e.g. Customs); of public health and related subjects (e.g. US PHS, Dept. of Agriculture); of control of navigable waters (e.g Army Engineers, U. S. Coast Guard); and of various labor relations. In some cases the effect of regulation is indirect, such as the necessity to provide facilities for agricultural inspection and fumigation of some types of cargo and also the facilities for customs inspection. Aids to navigation, such as channel markers, lights and ranges are provided and maintained by the U.S. Coast Guard.

1.3.2 STATE

State regulations cover generally the same fields as Federal, through various state industrial safety laws, vehicle codes and sanitary laws, and environmental control.

1.3.3 COUNTY AND CITY REGULATION

These generally are most prominent in the areas of zoning and of building codes. Several of the larger cities have adopted their own building codes; more generally, however, one of the nationally recognized building codes will be adopted by the city or county with the force of law. In case the project be located in an area where no code is made mandatory, it is then prudent for the owner to adopt the code most generally recognized in that area for all planning and design purposes. Any building code whether mandatory or adopted voluntarily, will need to be supplemented to cover the requirements of a marine terminal, for which there are in the U.S. no generally recognized standards. City and County regulations will also frequently govern the construction features and operation of food service establishments, such as must commonly be provided within the limits of a marine terminal.

The following draft of proposed Part 10 of Chapter 25 of the Manual is presented as information. Comments and criticism are invited.

Part 10

Operation

10.1 FIRE PROTECTION, SAFETY, SECURITY

10.1.1 FIRE PROTECTION

For each terminal, the overall supervision of fire protection standards and methods should be the responsibility of one person, who should closely coordinate his plans with the appropriate local fire-fighting agency. Original construction and subsequent change are subject to the approval of the insurance carrier. Detailed inspection by check list of the fire protection system and all its equipment at frequent intervals is good practice. Regular review of the system should be made to allow for possible changes in hazard rating, area usage, etc. Available head on city or other mains serving the terminal should be checked for maximum and minimum to be expected. It may be considered desirable to post in advance a Fire Emergency Plan covering all supervisory personnel, and may include any others necessary to the proper functioning of such a plan. This planning may well be expanded to cover other classes of emergency as well.

10.1.2 SAFETY

In accord with the published safety rules of the operating carrier and with the pertinent Federal and other regulations. Particularly noteworthy are those of OSHA and the U. S. Coast Guard.

10.1.3 SECURITY, FENCING AND LIGHTING

Generally these facilities should be completely fenced and have the minimum number of gates: only one if this be practical. To the maximum extent possible, all employee parking should be outside the terminal area fence. Under some labor contracts, however, this may not be feasible. Control of access may vary somewhat with the type of use, with the most severe restrictions applicable to facilities handling flammable or explosive cargo, and with just or nearly as severe restrictions for terminals handling readily pilferable cargo. Control of access involves not only access from land but from water as well; this can present a serious problem. The exercise of access control should be a function of the terminal operating agency. Lighting will generally be required for security purposes as well as for operation. Lighting for security purposes must be coordinated with the intended access control and with the type of patrolling planned. Floodlights must be so placed as not only to light the required area but also to avoid glare in the eyes of equipment operators, particularly where full portal or similar cranes with high operators position are used.

10.2 CONTRACTUAL RELATIONSHIPS

10.2.1 MARINE TERMINALS

Section in preparation.

10.2.2 FLOOD CONTROL PROJECTS

Section in preparation.

10.2.3 OTHERS

Section in preparation.

10.3 UTILITIES AND SHIPS' SERVICE

Minimum facilities would be a potable water supply with hoses to reach the ship's tanks, and safe access to and from the ship for personnel. For the later item, passage by seamen returning to the ship at night must be considered. A route entirely outside transit sheds and warehouses is preferable.

For ships making longer stays other services may be desired or required. Temporary telephone service, fuel and lube oil delivery, delivery of ships' stores, access for men and equipment making light repairs to the ship, collection of garbage or other waste from the ship; these all may be required. Rarely, a request for shore electric power may be made. For smaller craft, facilities for pumping sewage holding tanks may be necessary.

10.4 MECHANICAL EQUIPMENT

The full maintenance responsibility should rest with the organization controlling its use. This is particularly true in the case of leased equipment. Shop facilities adequate to the task should be conveniently located so as to minimize dead time on equipment. The inspection and certification of cranes and similar equipment as required by Federal law should be scheduled amply early that equipment will not be deadlined.

If for structural reasons certain mobile equipment is restricted from operation on certain areas, this must be clear and unmistakable to any operator of that equipment. The restrictions may be posted by warning signs on the equipment or at the entrance to the restricted area, or both.

10.5 MAINTENANCE RESPONSIBILITIES

10.5.1 INSPECTION CHECKLISTS

Provide inspection of load-carrying structures on a schedule appropriate to the type of structure and its use. Normally this inspection will be most productive if the inspector works from a check list suitable for the type of structure involved. For a new facility the preparation of such a check list may conveniently be done by the structural designer at time of construction. Inspection of piling, foundations and bulkheads beneath water level ordinarily must be by divers. In a few instances, water may be clear enough to permit a visual inspection from the surface. If divers are employed, the Scuba diver has better mobility than a helmet diver, but in strong currents may be at a disadvantage. Use of ultrasonic inspection methods for submerged timber piling can be useful, and in some instances may offer the only practical method of inspection. From time to time environmental changes may affect corrosion rate, decay, attack by toredo or other organisms, deterioration of concrete or coatings. These changes may be gradual and insidious. Thus it is prudent for the engineer under whose responsibility the marine structure may lie to maintain close contact with other organizations operating similar structures in the same area.

Some method of observation to detect ship collision or docking damage and promptly report this to the appropriate office is important, not only to initiate repair promptly, but also to assign responsibility for the damage.

10.5.2 Under-Dock Equipment

This usually consists of potable water lines, fire mains, sewer lines and sometimes sprinkler systems. In some jurisdictions draft curtains are required under wooden docks. Some portions of bollard anchorage may also be in this classification. The decisive characteristics of this class is the exposure to unusually severe corrosive or decay prone conditions. Coatings are not, in general, reliable. Anchorage of fire mains at bends and elbows is particularly critical.

10.6 SEASONAL OR ABNORMAL WEATHER PRECAUTIONS

In areas subject to hurricanes there should be for each terminal a plan for securing equipment, cargo and personnel against the wind and high water, remembering that the most serious damage is usually from rising and wind-driven water. The Weather Bureau, NOAA (formerly U.S.C.&G.S.), and the Corps of Engineers can furnish estimating values for possible or probable wind velocities and tide surge elevations. Cargo storage areas should be scheduled with these data in mind. Tie-down procedure for large equipment such as container cranes should be checked out in advance of each storm season. It may be considered undesirable to have ships at a particular moorage in case of hurricane; if so, ample notice must be given the ship to permit movement to a safe location.

Long period waves associated with earthquake have been damaging, particularly in British Columbia and Alaska, but could occur elsewhere. The main consideration here would be to have adequate warning in the event of an earthquake in a marine area.

Report on Assignment 3

Bibliography Relating to Benefits and Cost of Water Resource Projects of Interest to Railroads in the Areas of Flood Control, Storage, Drainage and Navigation

R. C. Rankin *(chairman, subcommittee)*, B. M. Dornblatt, W. H. Eschwig, J. E. Foreman, Jr., R. V. Gilbert, C. E. Gilley, F. J. Olsen, M. S. Patterson, G. A. Stenstrom, C. A. Still, R. A. Ullery, B. H. Voor, R. F. Weir.

Your committee presents as information the following draft of proposed Part 2—Waterways, of Chapter 25. Comments and criticisms are invited.

Part 2

Waterways

FOREWORD

The purpose of this part is to establish definitions of navigable and non-navigable waters.

2.1 NON-NAVIGABLE WATERS

2.1.1 General Definition

Non-navigable waterways include all waterways not declared as navigable streams by the Corps of Engineers, Department of Defense. The term "non-navigable" is difficult of precise definition, as will be noted from Art. 2.2.1 herein. On the one hand a stream may be classified as non-navigable in the instance that it cannot be used as a "highway of commerce;" but such "non-navigable" tributary of navigable streams may be controlled for navigation for purposes such as flood protection and water shed development, thus being declared "navigable."

The effect of non-navigable waterways upon the operation and maintenance of railroads is covered in AREA Manual, Chapter 1—Roadway and Ballast, Part 3—Natural Waterways.

2.2 NAVIGABLE WATERS

2.2.1 General Definition

Navigable waterways are all natural and man-made waterways declared as navigable streams by the Corps of Engineers, Department of Defense. Decision as to whether or not a stream is navigable rests on legal interpretations and not on any engineering formula or measurements.

2.2.2 Judicial Definition

Congress possesses the power to regulate navigation on inland waters by virtue of the grant of the commerce power in Article I of the Constitution of the United States. This fact is confirmed by court decisions of record.

One of the leading cases on the navigability of streams or rivers was decided many years ago by the United States Supreme Court, which said: "Those rivers must be regarded as navigable rivers in law which are navigable in fact, and they are navigable in fact when they are used, or are susceptible of being used in their ordinary condition, as highways of commerce, over which trade or travel are or may be conducted . . . and they constitute navigable waters of the United States . . . as distinguished from the navigable waters of the States, when they form in their ordinary condition by themselves, or by uniting with other waters a continuous highway over which commerce is or may be carried on with other States or foreign countries. . . ."

"Commerce" has been defined to denote navigation. The commerce power of Congress is limited to waters which are navigable for the purpose of interstate and foreign commerce and to non-navigable tributaries of navigable waters insofar as the utilization of the water of such tributaries will affect the navigable waters below.

2.2.3 Lands Subject to Servitude of Navigation

The bed of a navigable water is that portion of land lying below the ordinary high-water mark. Court decisions have established that the shores of navigable waters and the soils under them were not granted to the United States by the Constitution; but were reserved to the respective States. Within the limits of the commerce powers of Congress, the rights of the States, their municipalities and of riparian properties are subservient to the interest of interstate and foreign commerce.

Authority to perform work or place structures in navigable waters of the United States must be solicited from and granted by the Secretary of the Army before any work is done. Authority so granted is in the form of a permit which merely expresses assent of the Federal government so far as concerns the public rights of navigation. Consent to the actual work and/or structure must be obtained from State governments, local governments and/or private interests affected.

2.2.4 Bridges Over Navigable Waters

Effective March 1, 1968, the United States Coast Guard, Department of Transportation, assumed responsibility for bridges across navigable waters (Public Law 89–670).

Bridge permit applications should be obtained from, and processed through the Commander of the Local Coast Guard District.

The Coast Guard also issues regulations for requisite aids to navigation including, but not limited to, lighting of bridge, etc.

2.2.5 Clearances Over Navigable Waters

Horizontal and vertical clearances of structures and bridges in or over navigable waters are established by the Corps of Engineers, Department of Defense.

Report on Assignment 6

Planning, Construction and Maintenance of Rail–Water Facilities

J. C. FENNO *(chairman, subcommittee)*, R. L. BOSTIAN, W. E. CORBET, P. P. DUNAVANT, W. H. ESCHWIG, J. H. FITZPATRICK, J. E. FOREMAN, J. GRESSITT, E. C. LAWSON, R. L. PETTEGREW, G. A. STENSTROM, C. A. STILL, S. G. WINTONIAK.

Your committee presents as information the following drafts of proposed Parts 3, 4, and 6 of Chapter 25 of the Manual. Comments and criticisms are invited

Part 3

Harbors

FOREWORD

A harbor can be defined as a place of shelter or refuge, a haven, or a place to provide refuge from winds, waves and currents. Herein a harbor is considered as a port viewed in its commercial relations.

3.1 LOCATION CONSIDERATIONS

The location of a port depends upon the nature and type of materials to be handled, the geographical and geological nature of the site, access from water and land, availability of utilities, possible effects of pollution, industrial and commercial activities in the area, and land and water area available for present use and future development and expansion.

3.1.1 Type of Terminal

The type of terminal depends on the cargo to be handled and the origins and destinations of the cargo moving through the terminal.

3.1.2 Dock Facilities

Ship berths are influenced by the type, size and number of vessels, the present and future cargo, water level statistics, climatic and weather conditions and ranges, and the technical limitations of the soil. A study of the handling capacity is necessary, distinguishing between the high costs of major loading berths and the lower costs of auxilliary or waiting wharves.

3.1.3 Rail Facilities

Rail facilities should be located as close as possible to the ship berths to minimize handling, and access should be provided to all railroads in the area. Adequate marshalling areas in the immediate vicinity are desirable. The design should be in accordance with the recommendations set forth in the AREA Manual, Chapter 14.

3.1.4 Highway Facilities

Highway access should be convenient and adequate, with pavements of sufficient strength to handle highway loads with a minimum of maintenance. American

Association of State Highway Officials' standards shall be used in the design. Traffic control and security are a necessary part of the design. Traffic lines which would avoid conflict between the port and the town are desirable.

3.1.5 Utilities

Adequate public utilities should be available, including power, water, sewer, communication, fire-fighting, etc. There should be medical and first-aid facilities in the immediate vicinity, and facilities for the replenishment of ships stores. A possible need for stand-by facilities should not be overlooked.

3.1.6 Nature of Waterway

The nature of the waterway will influence the design of the terminal to a large extent. Winds, tides, waves, currents, corrosive effect of the water, and presence of marine borers are all items of concern. Currents affect silting conditions, depth of water and the frequency of costly dredging. Tidal range or river stage directly affects design and operation of transfer bridges.

3.2 RULES AND REGULATIONS

It can be held generally that the Federal government claims jurisdiction over all navigable water, with local government having secondary control. A proposed harbor facility will require approval of the project from all concerned.

3.2.1 National

Application for the project must be made to the appropriate Federal agency This is followed by a public hearing or hearings at which all interested parties may be heard. The Federal agency will normally require compliance with any local agencies retaining jurisdiction, particularly as regards environmental and pollution aspects.

3.2.2 Local

State and local agencies will require compliance with their standards. Zoning requirements must be met as well as any other local regulations, particularly in the area of public health and safety. It is advisable to clear all local requirements prior to application to the Federal agency.

Part 4

Design

4.1 LOADING AND STRESSES

4.1.1 Rail Supporting Structures

4.1.1.1 Timber

Design in accordance with Chapter 7, AREA Manual.

4.1.1.2 Concrete

Design in accordance with Chapter 8, AREA Manual.

4.1.1.3 Steel

Design in accordance with Chapter 15, AREA Manual.

4.1.2 Highway-Vehicle-Supporting Structures

Design in accordance with American Association of State Highway Officials Standard Specifications for Highway Bridges.

4.1.3 Non-vehicular Structures

4.1.3.1 Timber

Design in accordance with Design Manual of the American Institute of Timber Construction.

4.1.3.2 Concrete

Design in accordance with specifications of the American Concrete Institute.

4.1.3.3 Steel

Design in accordance with specifications of the American Institute of Steel Construction for Buildings.

4.1.3.4 Aluminum

Design in accordance with specifications of the American Society of Civil Engineers for Structures of Aluminum Alloys.

4.2 RULES AND REGULATIONS

See Part 3, Sec. 3.2, this Chapter.

4.3 MOORING DEVICES

4.3.1 Selection

4.3.1.1 Flexible Wood Pile Dolphins

Flexible wood pile cluster dolphins are generally used for mooring vessels of less than 5,000 tons displacement, or for fendering purposes.

4.3.1.2 Rigid Wood Platform

Rigid wood platform piling and framing are generally used for mooring vessels of up to 17,000 tons displacement.

4.3.1.3 Cellular Sheet Pile Dolphins

Cellular sheet pile dolphins are generally used for mooring vessels of up to 35,000 tons displacement. An adequate fender system must be provided.

4.3.1.4 Heavy Concrete Platform

Heavy platform concrete slabs supported on vertical and batter piles of steel, concrete or wood are generally used for mooring vessels of up to 110,000 tons displacement.

4.3.1.5 Mooring Buoy

The mooring buoy is used for anchorages and off-shore moorings, and may be designed to accommodate vessels of any size.

4.3.1.6 Fender Systems

Fender systems are required to absorb the energy of impact during berthing, to avoid damage by moored ship due to surge, heave, pitch and roll, to act as rubbing strips, and to deflect accidental contact at dock entrances.

4.4 WHARVES AND PIERS

Ship berthing facilities may be grouped into five general types: wharves located on slips dredged into the shore; finger piers projecting out from the shore; marginal wharves paralleling the shore; ferry-type slips; and off-shore berths.

4.4.1 Wharf Types

4.4.1.1 Pile platform over earth slope

4.4.1.2 Earth fill platform over slope.

4.4.1.3 Cellular cofferdam.

4.4.1.4 Sheet pile.

4.4.2 Pier Types

4.4.2.1 Fill between sheet piles.

4.4.2.2 Pile bents.

4.4.2.3 Fill with pile bents over slope.

4.4.3 Forces to Consider

Among the forces to consider as acting on marine structures are the frequency and distribution of swell and waves, the duration and direction of swell and waves, pressure and shock from ice if applicable, impact due to berthing and action of the ship while moored, and loading due to machinery, equipment and other loading on the land side. Earthquake and explosion factors may be applicable as well.

4.5 BREAKWATERS

4.5.1 Types

There are four general types of breakwaters: wall, mound or heap, cellular cofferdam, and combination mound and wall. They are costly to construct, and should provide the greatest area of enclosure of sufficiently deep water for the least extent of breakwater. Care must be exercised not to disturb the balance of the coast, which can result in erosion or deposition.

4.6 DOCKSIDE BUILDINGS

4.6.1 Transit Storage

4.6.2 Stevadore Offices

4.6.3 Passenger and Comfort Stations

4.7 MACHINERY AND EQUIPMENT

4.7.1 Shore-based Cranes

4.7.2 Conveyor Machinery

Design in accordance with the manual of the Conveyor Equipment Manufacturers Association.

4.7.3 Materials Handling Machinery

Design in accordance with standards of the American Material Handling Society or the Material Handling Institute.

4.8 UTILITIES

4.8.1 Electrical

Design in accordance with the Electrical Manual of the Engineering and Mechanical Divisions of the Association of American Railroads and applicable Electrical Codes.

4.8.2 Plumbing

Design in accordance with Chapter 13 of the AREA Manual and applicable Plumbing and Building Codes.

4.8.3 Streets and Drainage

Design in accordance with applicable portions of Chapters 1, 8 and 9 of the AREA Manual and construction and building codes.

4.9 EARTHQUAKE CONSIDERATIONS

Apply applicable codes where required or as desirable.

4.10 EFFECTS FROM EXPLOSIONS

It is recommended that consideration to the secondary effects of blast, shock and fragmentation be given in areas where dangerous materials are handled.

Part 6

Track and Transfer Facilities

6.1 CARGO TYPES

6.1.1 General Cargo

General cargo may be packaged or unpackaged and will include such items as bales, small cartons, drums, machinery, etc. General cargo presents difficulties in handling, storage and transfer, and will frequently require special facilities for refrigeration, salting and icing.

6.1.2 Bulk Cargo

Bulk cargo includes such items as grain, coal, cement, ore and liquid petroleum. Proper facilities such as conveyors and dumpers will provide for efficient handling and transfer.

6.2 TRANSFER FACILITIES

6.2.1 Roll-on, Roll-off

Roll-on/roll-off facilities include ferries, barges, and special vessels designed for direct transfer of railroad cars or vehicles, and enjoy the advantage of eliminating transfer of cargo. Costly equipment is not required, but sufficient area for loading and unloading and maneuvering is necessary. Design of the transfer bridge must provide for fluctuation in water level.

6.2.2 Lift-on, Lift-off

These require the use of cranes to transfer cargo. The advantage is the transfer of an entire package rather than small pieces of cargo, and elimination of the water level fluctuation effects. The handling of large, heavy loads presents many problems, and the economic solution may be the use of roll-on/roll-off facilities, or floating cranes. Standard containers are enjoying considerable use recently, and offer an additional advantage in reducing pilfering. Properly designed traveling portal cranes located on the pier apron reduce handling time. The cranes must be fast and maneuverable, and of sufficient lifting capacity to handle the expected loads.

6.2.3 Car Dumping

Car dumping facilities are used for certain bulk cargo, such as coal, ore and grain. The two general types are rotary and direct dumpers. The rotary dumper is fast and lends itself well to conveyor systems and automation. The direct dumper may involve an elevated platform and apron chute for direct loading into vessel, or can also be used in combination with hoppers and conveyors. Freezing and dust are major problems to be solved.

6.2.4 Conveyor Belts

Fully automated conveyor belts are especially applicable to the handling of solid bulk cargo, particularly when protection from the elements is not a requirement. They are also adaptable to the handling of small packaged goods and goods which do not lend themselves to packaging, such as bananas. A conveyor system must be flexible and capable of movement in more than one direction. Back-up facilities are essential and a large land area must be readily available for storage.

6.2.5 Pipe Lines

Bulk liquid cargo is usually handled by specially designed cars and ships, and the cargo is generally handled by a pipeline. Tank storage facilities are usually provided near the dock facilities. Flammable liquids require special safety precautions, and every effort must be expended to prevent spillage and pollution.

6.3 STORAGE

6.3.1 Marshalling Yard

A rail-water transfer facility will require adequate area for storage and handling of railroad cars. The location should be as close as possible to the water terminal, and must be provided with an efficient means of moving cars to the point of unloading and back. An efficient communication system is desirable. The design should be in accordance with Chapter 14 of the AREA Manual.

6.3.2 Warehouses

6.3.3 Bulk Storage Yard

The bulk storage yard must be of sufficient capacity to provide efficient flow of the cargo. Conveyors, stackers and reclaimers must be flexible enough to meet the maximum demands.

6.3.4 Tank Storage

Storage facilities for liquids must be of sufficient capacity to handle the maximum input and/or output. Rail loading and unloading facilities should be such that the flow of cargo is efficient and storage time is minimized. Security, safety and pollution control are essential.

6.3.5 Container Storage

Sufficient area must be provided for the efficient handling of all types of containers handled in the terminal. Containers moving by rail require marshalling yards with capacity to handle maximum moves, and yet minimize transfer moves. Truck and trailer types must be efficiently arranged to coordinate the moves from storage to loading area. Pavement in the container storage area must be designed to provide structural strength for severe use.

Report of Committee 6—Buildings

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R. Hale
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G. H. McMillan
L. S. Newman
L. A. Palagi
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H. A. Shannon, Jr.
J. S. Smith
S. G. Urban
O. G. Wilbur (E)
T. S. Williams (E)
C. B. Zimmerman

Committee

(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association.

Your committee reports on the following subjects:

B. Revision of Manual.

Work is in progress on the review of various reports previously submitted as information which will be developed as Manual material. Subjects being presently pursued are Pre-fabricated Buildings and a section to be added to Part 2—Design Criteria for Railway Office Buildings.

1. Buildings, Platforms, Ramps, Paving, Lighting, and Other Facilities for Piggyback Terminals.

"Design Criteria for Trailer-on-Flat-Car or Container-on-Flat-Car Facilities submitted for adoption and publication in the Manual as new Part 6 of Chapter 6 were published in Part 1 of Bulletin 640, November–December 1972.

2. Design Criteria for Diesel Service and Repair Shops.

Three committee workshops have been devoted to this subject and a final draft is now being prepared. It is anticipated that this material will be forwarded to committee members for letter ballot vote for inclusion in the Manual in the early part of 1973.

4. Design Criteria for Spot Car Repair Facilities.

"Design Criteria for Spot Car Repair Shops" submitted for adoption and publication in the Manual as New Part 3 of Chapter 6, were published in Part 1 of Bulletin 640, November–December 1972.

5. In-floor Conveyor Systems.
   A preliminary report was reviewed at the summer meeting and a final report is being prepared which will be submitted as information.

6. Computer Room Design.
   No report.

7. Pneumatic Tubes.
   A preliminary report was reviewed at the summer meeting and a final report is being prepared which will be submitted as information.

8. Portable Prefabricated Buildings.
   Final report, submitted as information, with the intention of submitting it to letter ballot vote for inclusion in the Manual in 1973 .... page 276

THE COMMITTEE ON BUILDINGS,
DON A. BESSEY, *Chairman.*

Report on Assignment 8

Portable Prefabricated Buildings

P. W. PETERSON *(Chairman, Subcommittee)* E. P. BOHN, C. M. DIEHL, J. W. HAYES, J. R. HURSH, C. R. MADELEY, L. A. PALAGI, J. G. ROBERTSON.

0.1 FOREWORD

Portable prefabricated buildings are fast making inroads in the railroad industry. Standard and custom-built units now provide almost limitless designs and material combinations to answer building requirements for railway use. The major limititation is unit size. Transportation clearances must be considered in each individual case. The economy, versatility and durability of these structures make them ideal for many applications.

The types of structures mentioned herein are those constructed by outside firms specializing in shop fabrication of component parts. Frame and metal type portable buildings can and have been field-constructed by railroad forces, but because of weather problems, crew transportation, material delivery, inexperience, etc., the cost of these units proves to be excessive compared to the shop-fabricated type in most instances.

0.2 SUITABILITY

Railroad facilities for which portable prefabricated buildings are suitable are as follows:

0.2.1 Yard and Shop Buildings

a. Lunch, locker and toilet buildings.

b. Yard offices.

c. Crew housing.
d. Supervisor offices (in-plant and other).
e. Switchmens' shelters.
f. Hostler houses.
g. Equipment storage buildings.
h. Utility buildings.
i. Pump houses.
j. Compressor buildings.
k. Crew caller offices.
l. Fire-fighting equipment storage buildings.

0.2.2 Maintenance of Way Buildings

a. Maintenance of way headquarters.
b. Motor car houses.
c. Truck garages.
d. Track machinery storage building.
e. Communication equipment buildings.
f. Signal equipment buildings.
g. Storage buildings.
h. Tool sheds.

0.2.3 Stations

a. Small stations.
b. Waiting shelters.
c. Combination passenger and freight stations.

0.2.4 Miscellaneous Buildings

a. Scale houses.
b. Field offices.
c. TOFC offices.
d. Microwave equipment buildings.

0.3 PORTABILITY

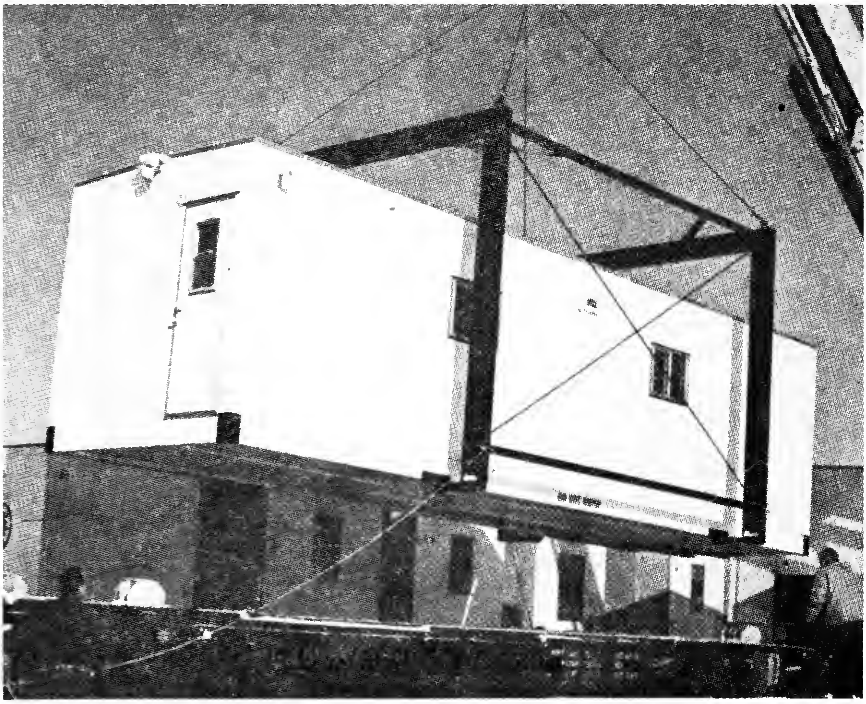
One of the main advantages of the portable prefabricated building is that once the utilities have been disconnected, it can be transported to another location and set in place with a minimum of expense. The buildings are so constructed as to minimize racking in shipment and can be transported on truck beds or flat cars; the mobile trailer type structures are provided with their own wheel and axle assemblies for highway travel. Precautions must be taken to secure the building to the mode of transportation used and carrier inspection is required. When building width requirements are greater than transportation clearances allow, some types of units can be constructed in multiple sections with splice joints in floor, end walls and roof which are connected and made weathertight at the site.

0.4 ECONOMY

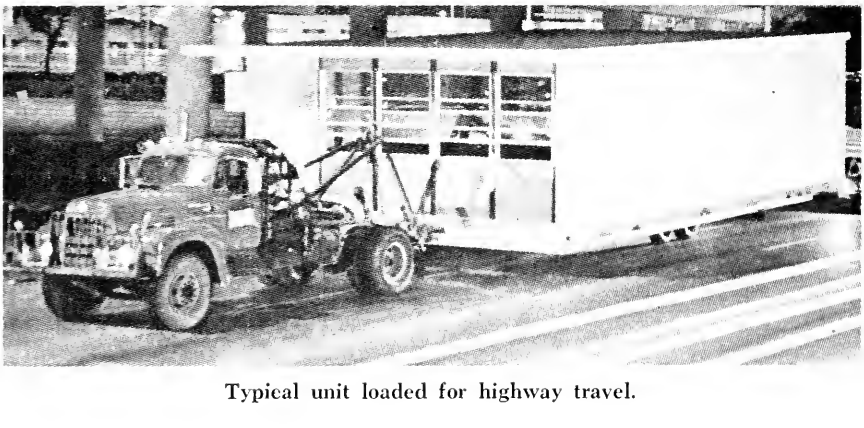
The economy of portable prefabricated buildings is derived from the following:

a. Modern shop production methods.
b. Volume material purchases.

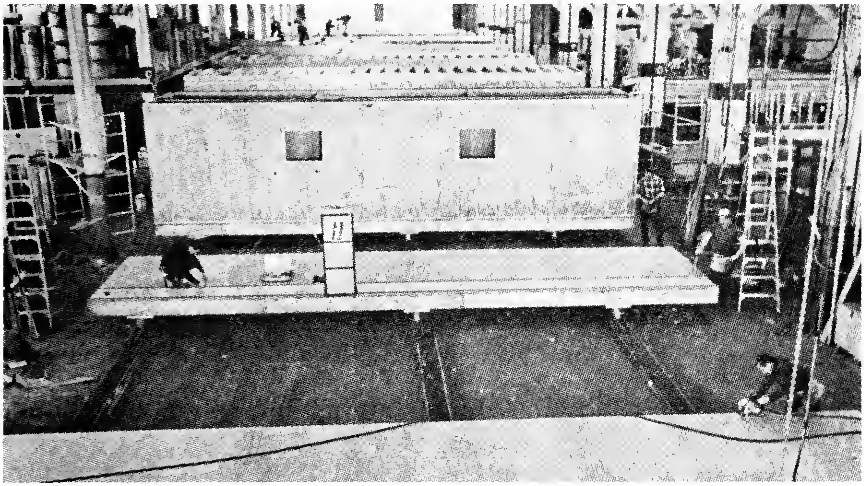
Designed for Transportability—



Unit being lifted by the use of a lifting frame, with sides of unit protected by steel lifting guides. Cables passed under the unit may also be used.



Typical unit loaded for highway travel.



Plant assembly of one type of portable prefabricated building.

c. Minimum foundation requirements.

d. Minimum maintenance because of materials used.

0.5 TYPES OF STRUCTURES AVAILABLE

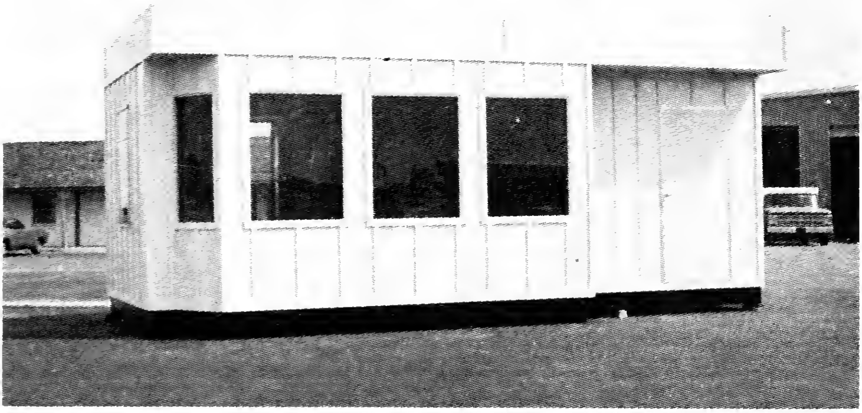
The fundamental types are as follows:

0.5.1 Metal Buildings

Metal buildings are fabricated from pre-engineered, mass-produced building parts conforming to the Metal Building Manufacturers Association "Code of Standard Practice." Size and design are governed by component modules which vary with the manufacturer. Wood or steel framed floor systems can be utilized. Wall coverings can be prepainted sandwich type insulating panels with integral interior metal lining or single sheeting with separate insulation and interior liner. Wood furring can be applied as another alternate and insulation and liner material of any type used. Roof configurations are usually flat, shed or gable, utilizing self-supporting metal panels that provide a weather seal without the aid of additional covering. Ceilings can be prepainted metal or wood-framed and finished with acoustic tile or almost any other material desired. Insulation can be added to suit design requirements. Partitions may be frame or metal and finished as desired.

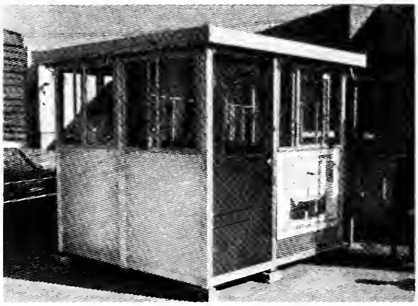
Metal building design is usually governed by stock components, and any variation from the manufacturer's standards would tend to increase the cost of fabrication. Standard accessories which are available are as follows:

1. Insulating windows and window wall units.
2. Personnel doors (solid or glazed).
3. Overhead, sliding or double swing doors.
4. Ventilators.
5. Louvers.
6. Gutters and downspouts.



Small station.

Pump house.



In-plant office.

Roadway buildings.

7. Skylights and wall lights.
8. Roof overhangs (eave and sidewall).
9. Special framed openings.
10. Insulations.

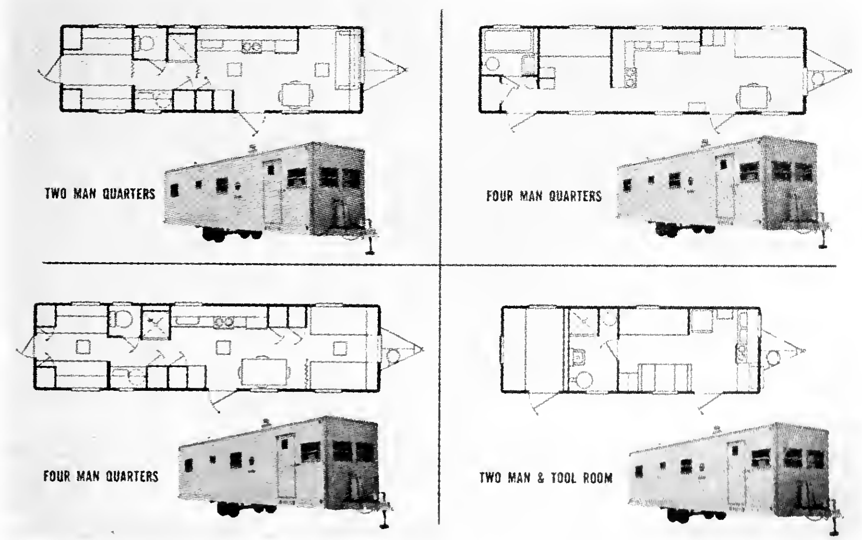
This type of building is usually furnished in component parts by the manufacturer for field erection by the owner or manufacturer's supplier.

0.5.2 Trailer-Type Unit

The prefabricated mobile trailer-type unit is also pre-engineered and fabricated mainly from stock parts. It has an all-steel, arc-welded heavy-duty dual type substructure, specifically designed to withstand heavy service requirements, off-road use and movement by truck or rail. The unit can be equipped with running gear assemblies consisting of tandem axles with multi-leaf springs and equalizing bar suspension, four-wheel brakes (electric or hydraulic), and heavy-duty wheels with tubeless tires. Wall and roof assemblies are primarily steel or wood-framed and insulated throughout. The exterior is covered with a metal skin with a baked enamel finish. Exterior body corners and roof rails are reinforced to provide extra rigidity and impact resistance. The entire shell assembly is usually secured to the frame by means of steel shear plates, permanently joining the two basic assemblies into one integral structural unit. The frame is complete with a heavy-duty ball hitch and adjustable jack. The floor assembly usually consists of wood joists, plywood subfloor, particle board and commercial-grade floor tile. An aluminum weather shield is usually installed between the floor assembly and frame. Interior walls and ceilings can be pre-finished paneling, aluminum bonded to plywood, painted plywood, or metal.

Standard accessories available are as follows:

1. Prefinished aluminum entrance doors.



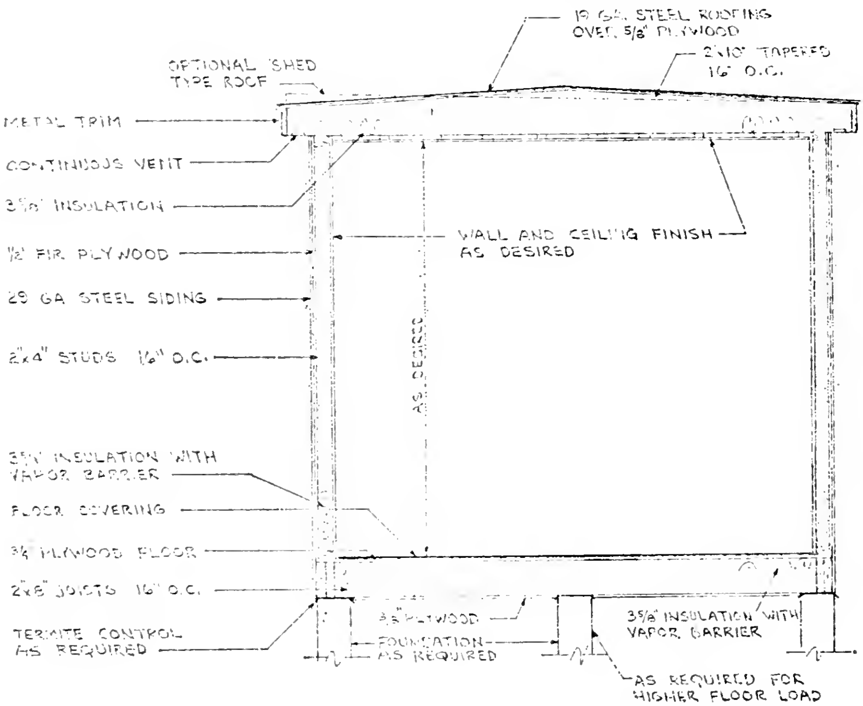
Typical floor plans, trailer-type unit.

2. Aluminum windows.
3. Complete bathroom facilities (gas or electric toilets available)
4. Complete kitchen facilities.
5. Complete electrical system including heat (installed in compliance with the National Electrical Code).
6. Gas or oil-fired furnace with under-floor duct system and thermostat control.
7. Air conditioning.
8. Thermostat-controlled electric heat tape for all internal plumbing lines.
9. Power generator.
10. Built-in water storage tanks with electric or hand-operated pressure system and switch over valves for water main supply.
11. Beds or bunks.

0.5.3 Wood Frame Buildings

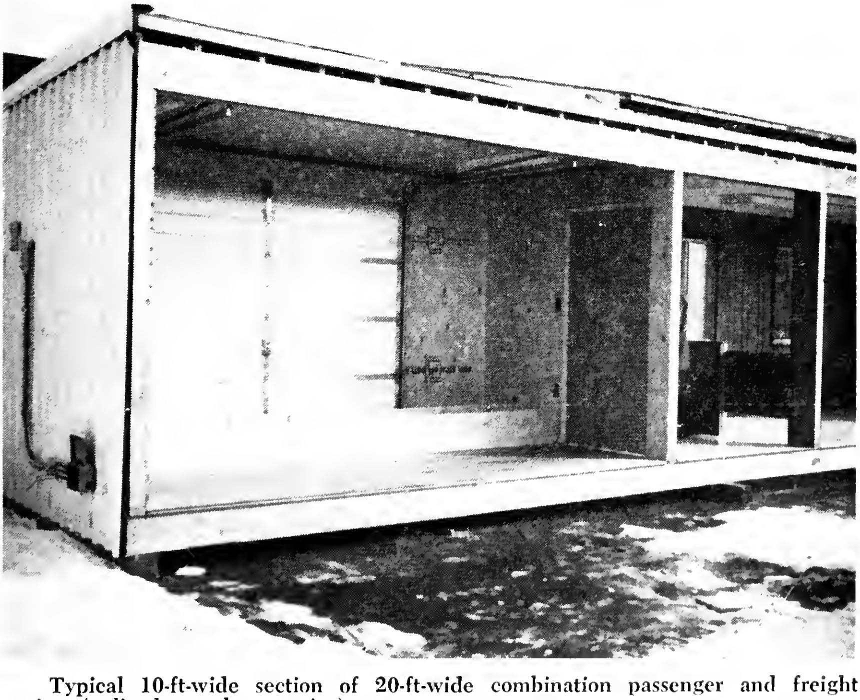
Wood frame buildings may be custom-fabricated to meet any requirement. Frame roof, wall and floor assemblies lend themselves to economy, especially if the units can be mass-produced. Stacking units have now become a reality for multi-story applications.

Manufacturers use modern practices in the manufacturing and fabrication of material. Plywood is extensively used in floors, roofs and walls to assure structural



Cross section through typical prefabricated wood frame building.

Typical small section building (12 ft wide) ready to load on flat car.



Typical 10-ft-wide section of 20-ft-wide combination passenger and freight station (spliced together at site).

Station building, 10 ft by 32 ft.

rigidity which will permit long-distance hauling without racking or distortion of the unit. The strength of members and connections should be determined by accepted methods of structural analysis. Certified test data and structural analysis should be made available if required by local or state codes.

Framing materials are designed and fabricated so as not to exceed allowable unit stresses as given by the Wood Structural Design Data, National Lumber Manufacturer's Association for the stress grades and species of lumber used. Required design loads must be specified by the owner.

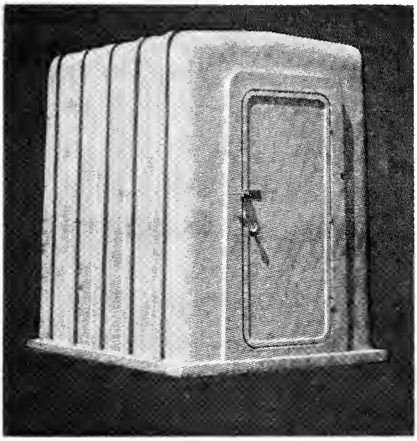
0.5.4 Precast Concrete

Precast concrete structures have been prefabricated by a few firms and there has been some usage in the railroad industry, mainly for signal and communication equipment houses. This type of structure is extremely permanent, but because of its weight, heavy equipment must be implemented to move and place the unit. This factor must be considered when analyzing cost.

0.5.5 Moulded Fiberglass

Moulded fiberglass structures are an innovation in the building systems field, utilizing the most modern materials. These units are constructed of lightweight, moisture and vermin-proof materials which will not sustain fire (self extinguishing). Buildings are stocked in several small sizes but custom sizes and designs are available. They are particularly adaptable for equipment shelters.

Electronics equipment shelter



0.6 SERVICES AVAILABLE

Heating, air conditioning, ventilation, wiring, lighting and plumbing can be installed complete as specified by the owner. The manufacturer must be informed of any special requirements such as:

a. Cooling loads
b. Lighting requirements.
c. Special wiring.
d. Type of heating system desired and fuel preference.
e. Air change required for ventilation.

0.7 SITE PREPARATION

A cleared and reasonably accessible construction site must be provided for ease in placement of the structure on the foundation.

0.8 FOUNDATION REQUIREMENTS

Secondhand treated timber sills, concrete block piers or reinforced concrete footings and floor slab must be provided, depending on personal choice or if called for by governing codes. Proper anchorage of building to foundation must also be provided.

0.9 CODE REQUIREMENTS

Code requirements vary greatly over the country, but portable prefabricated buildings can be engineered and fabricated to meet most codes with the possible exception that fire and occupancy zoning or esthetic objections from local planning agencies may preclude their use.

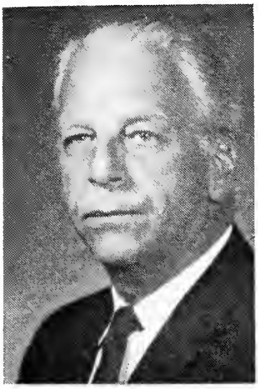
0.10 DRAWINGS

On any variation from standard or stock units, the manufacturer should be furnished a drawing and/or specification indicating exact requirements. The manufacturer should in turn furnish a complete set of shop drawings for approval.

0.11 SUMMARY

This report has attempted to show the vast potential for prefabricated portable buildings in the railroad industry. Much wider application can be envisaged in the years to come. Planners and designers should familiarize themselves with the many types available and the characteristics of each so as to be able to discern their adaptability for a particular application.

Report of Committee 7—Timber Structures



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J. W. Chambers, *Secretary*

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I. W. Thomas
W. A. Thompson
N. E. Whitney
S. J. Zajchowski
Committee

(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.

The task of converting Chapter 7 of the Manual to the decimal system has been completed by the subcommittee. Their report will be ready for presentation to the committee membership for its approval at our first meeting in 1973.

2. Grading Rules and Classification of Timber for Railway Uses.
Subcommittee will have new proposed grading rules and specifications report for submission to the entire committee at the next committee meeting in early 1973.

3. Specifications for Design of Wood Bridges and Trestles.
No report.

4. Methods of Fireproofing Wood Bridges and Trestles, Including Fire Retardant Paints.

No report. Waiting results of test by a large western road on a new material.

5. Design of Structural Glued-Laminated Wood Bridges and Trestles.
Subcommittee is in the process of revising design specifications for glued-laminated beams.

6. Evaluation of Cost on Various Sizes of Bridge Timbers.

No report.

7. Repeated Loading of Timber Structures.
   Subcommittee is preparing an interim report on last series of tests performed at the AAR Research Center. There will probably be no further work done on this assignment, as no funds have been allocated for this work.

9. Study of In-Place Treatment of Timber Structures.
   No report.

10. Non-Destructive Testing of Wood.
   No report.

THE COMMITTEE ON TIMBER STRUCTURES,
J. J. RIDGEWAY, *Chairman.*

Sidney F. Grear
1885-1972

Sidney F. Grear, retired assistant engineer of bridges of the Illinois Central Railroad (now Illinois Central Gulf Railroad), died on September 26, 1972, at Anna, Ill. at the age of 87.

Mr. Grear was born in Anna on June 14, 1885. He obtained his higher education at the University of Illinois, receiving a B.S. Degree in 1907. Mr. Grear started his career with the Illinois Central on July 27, 1907, as an engineering assistant on the Louisville division. Subsequently he served with the same railroad as rodman, draftsman, assistant engineer, chief draftsman, and office engineer, becoming assistant engineer of bridges on June 1, 1927 which position he held at the time of his retirement in August 1952, after 45 years of continuous service.

Mr. Grear became a member of AREA in 1920 and a Life Member in 1953. He was an active member of Committee 7, joining it in 1927. He was Chairman from 1945–1948 and became a Member Emeritus in 1954. He was also a member of Committee 30 in the years 1936–1953.

Mr. Grear was also a member of American Wood Preservers' Association.

Report of Committee 8—Concrete Structures and Foundations

F. A. Kempe, *Chairman*
T. L. Fuller, *Vice Chairman*
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R. E. Pearson
G. W. Cooke
J. R. Williams
J. M. Williams
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E. D. Ripple
E. E. Runde
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M. P. Schindler
J. E. Scroggs
J. R. Shafer
R. K. Shortt
L. F. Spaine
C. H. Splitstone (E)
R. G. Stilling
S. A. Stutes
A. Tedesko
W. C. Teng
M. F. Tigrak
W. J. Venuti
E. Watson, Jr.
J. W. Weber
J. O. Whitlock
W. R. Wilson (E)
G. A. Wolf

Committee

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* Died September 20, 1972.
(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman and vice chairman, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual
Manual recommendations submitted for adoption were published in the Manual Recommendation part of Bulletin 640, November–December 1972.

1. Design of Masonry Structures, Collaborating as Necessary or Desirable with Committees 1, 5, 6, 7, 15, 28 and 30.
Brief progress report and revisions to preliminary specifications for lightweight aggregate for structural concrete, submitted as information .. page 290

2. Foundations and Earth Pressures, Collaborating as Necessary or Desirable with Committees 1, 6, 7, 15 and 30
Brief progress report and Caisson Specification submitted as information .... page 291

3. Prestressed Concrete for Railway Structures, Collaborating as necessary or desirable with Committee 6.

   Brief status statement, submitted as information .... page 297

4. Waterproofing for Railway Structures, Collaborating as necessary and Desirable with Committees 6, 7 and 15.

   Brief progress report and proposed rubberized asphalt and plastic film membrane waterproofing system submitted as information .... page 297

THE COMMITTEE ON CONCRETE STRUCTURES AND FOUNDATIONS,
F. A. KEMPE, *Chairman*

Report on Assignment 1

Design of Masonry Structures

R. E. PEARSON *(chairman, subcommittee)*, W. E. BRAKENSIEK, L. CHIEFETZ, M. J. CRESPO, J. T. DOHERTY, R. A. DORSCH, J. A. ERSKINE, W. L. GAMBLE, C. W. HARMAN, R. H. KENDALL, R. H. LEE, H. B. LEWIS, G. F. LEYH, J. R. MOORE, J. A. PETERSON, J. A. SAWYER, JR., A. TEDESKO, J. W. WEBER, G. A. WOLF.

Revisions to Chapter 8 Manual material submitted for adoption were published in Part 1 of Bulletin 640, November–December 1972.

Last year your committee presented as information preliminary Specifications for Lightweight Aggregate for Structural Concrete, which were published in Bulletin 636, January–February 1972, pages 398–404. A large amount of comment was received. The following revisions and addendums are the result thereof and are presented here as information.

Revise Table 1, page 399, by adding to the bottom of the table:

	½ in	*⅜ in*	*No. 4*	*No. 8*
⅜ in. to No. 8	100	80–100	5–40	0–20

Reduce the number of cycles required in the magnesium sulphate test. Sec. 7h, page 401 from 13 to 10. This on the basis of many tests conducted by a private testing laboratory.

Revise Sec. 9f, page 403 to read:

> f. Freezing and Thawing—Make freezing and thawing tests of concrete when required, in accordance with one of the following methods: ASTM C 666–71, Test for Resistance of Concrete Specimens to Rapid Freezing and Thawing in Water, or ASTM C 666–71, Test for Resistance of Concrete Specimens to Rapid Freezing in Air and Thawing in Water.

Revise the table, Typical Example of Recording Test Results, page 404, by changing the last two lines to read:

⅜ in.	No. 2	51.5	2.2	1.13
Total Weighted Loss				5.17

Report on Assignment 2

Foundations and Earth Pressures

Collaborating with Committees 1, 6, 7, 15 and 30

G. W. Cooke *(chairman, subcommittee)*, W. B. Cole, G. F. Dahlquist, M. T. Davisson, B. M. Dornblatt, D. H. Dowe, R. J. Hallawell, P. Haven II, T. R. Kealey, E. F. Manley, E. C. Mardorf, D. Novick, M. P. Schindler, S. A. Stutes, W. C. Teng.

Revisions to Manual material submitted for adoption were published in Part 1 of Bulletin 640, November–December 1972.

Submitted for information is the following Specification for Drilled Shafts and Caissons. In connection therewith, attention is called to an article, "Suggested Design and Construction Procedures for Pier Foundations" reported by ACI Committee 336 and published in the August 1972 *ACI Journal.*

PRELIMINARY

SPECIFICATION FOR DRILLED SHAFTS AND CAISSONS

A 1 GENERAL

A 1.1 Scope

These specifications cover the description, design, installation, inspection and testing of drilled shafts and drilled caissons.

For the purpose of this specification, the minimum diameter of these units shall be 24 inches. Smaller diameters do exist but are not included in this specification.

For economic design individual units should be designed for much higher loads than those permitted on driven piles as specified in Part 4, this Chapter.

A 1.2 Definitions

1.2.1 A "foundation column" is a concrete-filled drilled or dug caisson or shaft used to transmit loads to a satisfactory subsurface formation.

1.2.2 "Drilled shafts" are concrete-filled foundation columns. They do not have permanent casings and are installed with or without bottom bells. They may be hand- or machine-excavated, extending to solid rock, hardpan or other satisfactory bearing materials.

1.2.3 "Drilled caissons" are foundation columns lined with permanent steel casings, which may be advanced using pile-driving methods. They are concrete-filled and may be formed with or without bottom bells. They may be hand- or machine-excavated, extending into solid rock, hardpan or other satisfactory bearing material. Where heavy loads are to be carried, this type may consist of a steel core section, and a concrete shaft terminating in a rock socket.

A 1.3 Purpose

The selection of foundation treatment for a given site is usually determined by economic considerations since there is often a choice of several types of foundations for any structure.

PRELIMINARY

Drilled shafts and caissons are used to transmit loads through soils of poor bearing capacity to or into a formation having adequate bearing capacity

A 2 INFORMATION REQUIRED

A 2.1 Field Survey

Sufficient information shall be furnished in the form of a profile and cross-sections to determine general design and structural requirements. The location of underground utilities, existing foundations, roads, tracks, or other structures shall be indicated. Records pertaining to high and low water levels and depth of scour shall be provided for river crossings.

A 2.2 Soil Investigation

Foundation soils shall be investigated as specified under Chapter 1, Part 1, Section 1.1 Exploration and Testing, in order to determine the bearing capacity of the deep foundations involved.

Reference is also made to Chapter 8, Part 4, Section C, Article 1 Soil Investigation, for additional information.

A 3 DESIGN

A 3.1 General

The design is divided into three basic parts: (1) The transfer of load from the column to the rock or bearing strata. (2) The column itself. (3) The connection between the supported structure and the foundation column.

A 3.2 The Transfer of Load from the Column to the Rock or Bearing Strata

3.2.1 Foundation columns transfer load to the bearing strata in one of three ways. Belled columns are enlarged at their base, providing more bearing area than column area. Straight shaft columns provide a bearing area equal to the column area. Socketed columns, by penetrating the bearing strata, transfer load by bearing and shear.

3.2.2 When the foundation column is subjected to lateral load and moment as well as vertical load, the distribution of soil pressures and the variation of moments and shear in the column shall be determined by current acceptable design practices.

3.2.3 Where the foundation column is short, the applied moment may be distributed between the base or socket and the side pressure in accordance with the relative stiffness of each. In this case, the moment taken by the base or socket shall be used in their design.

3.2.4 Where a distribution of moment has been made between the base and the sides of the foundation column, the portion distributed to the base will be used in designing the load transfer to the bearing strata.

3.2.5 Straight Shaft Columns:

3.2.5.1 Straight shafts may be used to bear on a material of relatively high bearing value.

3.2.6 Belled Columns:

3.2.6.1 Where the bearing strata has insufficient strength to support the load on the base of the column, the column base may be enlarged by

PRELIMINARY

belling to reduce the pressure by distributing the load over a greater area.

3.2.6.2 Belled columns shall be used only where the soil in which the bell is placed will not collapse due to the undercutting.

3.2.6.3 Since bells are normally unreinforced, the base diameter of the bell shall not exceed three times the column diameter and the sides shall not be less than 60° from the horizontal.

3.2.7 Socketed Columns:

3.2.7.1 By socketing foundation columns into rock, loads of greater magnitude can be transferred to the rock by a combination of end bearing and shear.

3.2.7.2 The socket is to be proportioned so that the load is transferred to the rock by bearing on the end of the socket at the allowable bearing value of the concrete, and the remainder of the load is transferred by shear on the socket walls at the allowable bond value of the concrete. In accordance with this procedure, the required depth of rock socket may be determined by the following formula:

$$\text{Socket depth, in inches} = \frac{R - O.\ 35 f'_c\ A_c}{0.05 f'_c\ C_s}$$

R = design load (vertical) at the base of foundation column.

f'_c = compressive strength of concrete in socket, but not to exceed three times the allowable bearing pressure on the rock.

A_c = area of concrete socket.

C_s = circumference of socket.

The depth of rock sockets shall not be less than the diameter of the shaft.

3.2.7.3 Since high unit stresses are assigned to socketed columns, it is essential that sockets be cleaned and good concreting practice be maintained.

3.2.8 Columns Under Water:

3.2.8.1 Wherever practical, the foundation column shall be so designed as to permit the placing of the concrete in the dry and the visual inspection of the hole, the bearing strata, and the rock socket.

3.2.8.2 When it is impractical to dewater the excavation for foundation columns, the concrete may be placed under water by means of a tremie, and appropriate allowances made in the design.

A 3.3 The Column

3.3.1 The foundation column is generally designed as a short column due to the lateral support provided by the soil.

3.3.2 When the foundation column is subjected to vertical load only, the short column may be designed by the following formula:

Allowable load $P = 0.225 f'_c A_c + f_s A_s + f_r A_r + f'_s A_s$

A_c, A_s*, A_r and A'_s = Area in square inches of concrete, steel pipe, structural steel core, and reinforcing steel respectively.

* Where corrosion may be expected, 1/16 inch shall be deducted from the shell thickness in computing the effective area of the shell.

PRELIMINARY

f'_c = compressive strength of concrete in 28 days.

$f_s = 0.40f_y$ for steel with f_y not greater than 30,000 psi.

$f_r = 0.50f_y$ for core section with f_y not greater than 36,000 psi.

f'_s = nominal working stress in reinforcement as given in Sec. D, Article 3.

A 3.4 Connection Between Supported Structure and Foundation Column

3.4.1 The connection between the foundation column and the supported structure (parts above the top of column) shall be capable of transferring the design loads, including direct load, shear and moment. This can be accomplished by the following means:

3.4.1.1 When the supported structure at the top of column is of concrete, the caisson shell, the steel core and the reinforcing are extended into the cap so that the load is transferred into the embedded steel of the foundation column by bond and into the concrete by compression.

3.4.1.2 When the cap section is a steel element, appropriate design shall be developed to transmit all loads.

A 4 MATERIAL

A 4.1 Concrete

Unless otherwise stipulated in this specification, concrete shall be produced and placed in accordance with the AREA Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, of this Chapter. Concrete shall have a minimum compressive strength of 3,000 psi in 28 days. Approved admixtures may be used to improve workability.

A 4.2 Reinforcing Steel

Unless otherwise stipulated in this specification, any required reinforcing steel shall be furnished as specified previously in this Chapter under Part 1, Sections E and H.

A 4.3 Structural Steel

Structural steel shall be as specified in AREA Manual Chapter 15, Part 1 or Part 2.

A 5 CONSTRUCTION

A 5.1 Contractor Qualifications

Drilled foundation columns shall be installed by a contractor or subcontractor who specializes in such work. Availability of all required special equipment, tools and experienced personnel is an important item to be considered when selecting an installation contractor.

A 5.2 Shaft

When drilling a foundation column, earth walls shall be adequately and securely protected when necessary against cave-ins, displacement of surrounding earth, and for the retention of ground water by means of temporary or permanent steel cylindrical casings.

PRELIMINARY

When personnel are required to enter the shaft, the shaft shall be cased and there shall be adequate provisions for fresh air, light and protection from falling objects. Operation of harmful-gas-producing equipment in the shaft must be prohibited.

Rock grapples or special tools for removal of boulders or other obstructions must be readily available for use.

Excavated material shall be disposed of by contractor unless otherwise provided for.

A 5.3 Casing

Any required steel casing shall be installed to the plan elevation or to the elevation designated by the engineer in the field. When the top of the foundation column is below the surface of the ground, installation of additional larger diameter casing may be required to extend above the working level to minimize possibility of foreign materials or water entering the top of the shaft.

Casings shall be of adequate size and of a thickness to safely retain the adjacent soil from entering the shaft excavations, without exceeding allowable steel stresses, distortion, or collapse of the casing.

A temporary steel casing is also to be provided where required to serve as protection for personnel entering the shaft excavations not provided with casings as specified above.

A 5.4 Bells

When caissons are required to be belled, the bells shall be formed either by hand or by use of special belling equipment to the angle and slope called for on the drawings, with level bottoms thoroughly cleaned of all loose materials. Before belling, the engineer shall determine that the formation encountered at the plan elevation is adequate.

A 5.5 Sockets

When sockets are required they shall be formed by machine or by hand to the proper size and depth as called for on the plans. Sides and bottom sockets must be thoroughly cleaned of all loose material since the bond of the concrete to the socket sides is used in design.

A 5.6 Tolerances

The center of the top of each shaft shall not vary from its designed location by more than 6 inches and the shafts shall be plumb to within ⅛ inch per foot.

A 5.7 Dewatering

Suitable dewatering practices shall be as agreed upon between the contractor and the engineer.

A 5.8 Inspection

Prior to placement of any required reinforcement, steel core or concrete, each shaft shall be thoroughly inspected by the engineer to ascertain that the shaft has been properly prepared, that the bearing material is compatible with design requirements, and whether additional investigation of the bottom is required.

PRELIMINARY

When bells are required, investigation of the material to be belled must be made to ascertain its ability to be undercut.

A 5.9 Placing Steel

When reinforcing steel or a structural steel core is specified, it shall be prefabricated and placed as a unit immediately prior to concreting operations. It shall be securely blocked in position so no displacement occurs during concrete placement or casing withdrawal operations.

A 5.10 Placing Concrete

Dry Hole—Prevent segregation of concrete through use of tube, sectionalized pipe or bottom dump bucket.

Under Water—Utilize a tremie in accordance with Chapter 8, Part 1, Section M, Article 10.

No rodding or mechanical vibrating shall be permitted.

The concrete placement method to be used shall be as agreed upon between the engineer and the contractor after such conditions as depth of column, presence of reinforcing steel, and water situation have been considered.

A 5.11 Casing Removal

In cases where the casing is to be removed, the head of concrete inside the casing must be adequate to preclude infiltration of water and sluffage of the shaft face. Elapsed time between concrete placement and casing withdrawal shall be at least 30 minutes.

In the event of suspected upward movement of concrete in the casing during concreting operation, extent of movement must be ascertained. No upward movement of the concrete can be tolerated.

A 5.12 Continuity of Work

Drilled foundation column construction work shall be planned so all required operations proceed in a continuous manner until the column is complete and ready to receive loading. A precise time schedule agreement between the contractor and the engineer should be established.

A 5.13 Records

An accurate record shall be kept of each column as installed. The record shall show the top and bottom elevations, shaft, and bell diameters, depths of test holes if required, date the column is poured and any other pertinent data. Records shall be made and signed by both the project superintendent and inspector and distributed to proper authorities daily.

A 6 TESTING

Materials used in construction of foundation columns should be sampled and tested as specified elsewhere in Chapter 8.

Further testing of the columns may be required by the engineer in order to determine the quality of the concrete by coring; or the bearing capacity of the column by test loading.

Report on Assignment 3

Prestressed Concrete for Railway Structures

J. R. Williams *(chairman, subcommittee)*, W. F. Baker, R. J. Brueske, J. W. DeValle, M. E. Dust, F. C. Edmonds, T. L. Fuller, G. W. Gabert, W. A. Hamilton, W. R. Hyma, G. F. Leyh, J. E. Peterson, E. D. Ripple, J. E. Scroggs, R. K. Shortt, L. F. Spaine, M. Fuat Tigrak, W. J. Venuti, J. O. Whitlock, W. R. Wilson.

Your committee reports progress toward the field testing of prestressed concrete bridge ties for open-deck construction on steel girders. A structure has been selected, a tie design for that structure has been completed, arrangements for testing have been negotiated and arrangements for manufacture of the ties are now under way.

Report on Assignment 4

Waterproofing for Railway Structures

J. M. Williams *(chairman, subcommittee)*, H. C. Brown, W. P. Hendrix, H. W. Hopkins, A. K. Howe, J. R. Iwinski, L. Lange, Jr., M. Pikarsky, H. D. Reilly, E. E. Runde, R. G. Stilling.

Your committee is continuing to investigate new waterproofing materials as they become available commercially and offers the following proposed specification for information (see next page):

PRELIMINARY

PROPOSED RUBBERIZED ASPHALT AND PLASTIC FILM MEMBRANE WATERPROOFING SYSTEM

MATERIALS

Waterproofing shall consist of a preformed rubberized asphalt and plastic film membrane with primer and cold-applied rubberized asphalt mastic.

Membrane shall be a minimum of 0.060 in. thick.

PERFORMANCE REQUIREMENTS

Property	*Requirement*	*Test Method*
Permeance–Perms (grains/sq. ft./hr./in. of mercury)	0.1 max.	ASTM E 96, Method B
Water Absorption—72 hr. (% by wt.)	0.25% max.	ASTM D 1228
Accelerated aging—400 hr. min.	no deterioration	ASTM D 822 and ASTM E 42 (procedure 4 f)
Exposure to fungi in soil—16 weeks	unaffected	GSA–PBS–4–0711 (spec.)
Pliability—180° bend over ¼-in. mandrel—35° F	unaffected	ASTM D 146
Peel Adhesion — 7 days dry + 7 days @ 120 F + 7 days dry (lb./in. width)	5.0 min.	TT–S–00230 Modified
Peel Adhesion — 7 days dry + 7 days @ 120 F + 7 days water immersion (lb./in. width)	5.0 min.	TT–S–00230 Modified
Crack bridging on application (in.)	3/16	
Cycling over crack at — 35 F (crack opened and closed from 0 to ¼ in.)	100 cycles min.	(TT–S–00230 TT–S–227) Modified
Puncture resistance (lb.)	40 min.	ASTM E 154

CERTIFICATION

Manufacturer shall furnish certification that materials meet specification requirements.

SAMPLES

A square foot sample shall be furnished for testing, when required, for each 2000 sq. ft. of membrane to be supplied.

SURFACE PREPARATION

1. All concrete or masonry surfaces shall be cured for a minimum of seven days and shall be surface dry. Surfaces shall be broom cleaned, shall be free of voids, loose aggregate, sharp protrusions, and from release agents of other contaminants. Horizontal concrete or masonry surfaces shall be wood float finished.

PRELIMINARY

2. All concrete or masonry surfaces shall be primed with manufacturer's recommended primer, applied by brush or roller at the rate of 250 to 350 sq. ft. per gal. Primer shall be dried one hour or until tack free. Primed surfaces not covered within 36 hours shall be reprimed. Dense surfaces such as metal shall not be primed, but shall be clean, dry, and free of grease, oil, dust, or other contaminants. Wood shall be primed.

APPLICATION PROCEDURES

1. All corners shall be double-covered with a double layer of membrane by applying an initial 12-in. strip centered along the axis of the corner. A cant strip shall be used on interior corners. Exterior corners shall be chamfered or rounded.

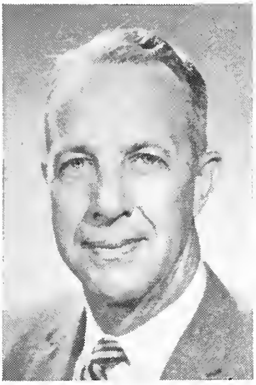
2. Construction and control joints shall be double covered with membrane. Prior to waterproofing over expansion joints, a minimum 12-in.-wide galvanized 16-gauge steel plate shall be placed and centered on the joint, then an inverted strip of membrane (plastic side down) 4 in. wider shall be centered on the galvanized plate. This should then be covered over with a full width of membrane, centered on the joint.

3. The perimeter of the membrane placed in any day's operation and all outside edges of membrane shall have a trowelled bead of cold-applied rubberized asphalt mastic applied after the membrane is placed.

4. Areas around drains, posts, bolts, or other protrusions shall have a double layer of membrane and shall be liberally coated with mastic adjacent to seams and protrusions after application of the membrane.

5. Immediately before covering the membrane, a careful inspection shall be made and any ruptures, misaligned seams or other discontinuities shall be patched with membrane.

Report of Committee 15—Steel Structures



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R. H. Wengenroth
Wm. Wilbur
A. J. Wood
M. O. Woxland
Committee

* Died May 1, 1972.
(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.
Revisions to the specifications for Steel Railway Bridges submitted for adoption were published in Part 1 of Bulletin 640, November–December 1972.

3. Protection of Steel Surfaces.
No report.

7. Bibliography and Technical Explanation of Various Requirements in AREA Specifications Relating to Steel Structures.
No report.

10. Continuous Welded Rail on Bridges, Collaborating as Necessary or Desirable with Committee 31.

No report.

THE COMMITTEE ON STEEL STRUCTURES,
M. L. KOEHLER, *Chairman.*

David Dean Rosen
1919-1972

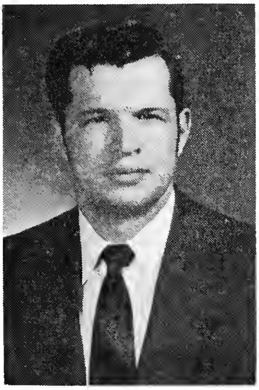
David Dean Rosen, assistant engineer for the Atchison, Topeka & Santa Fe Railway, passed away at Topeka, Kan. on May 1, 1972.

Born at Topeka on October 14, 1919, Mr. Rosen received his higher education at the University of Kansas from which he was graduated with a degree of B.S. in Civil Engineering. His military service in World War II included action as a Lieutenant in the Air Corps in New Caledonia in the Pacific Theater. Following the military service, Mr. Rosen devoted over 26 years of continuous service to the Atchison, Topeka & Santa Fe, working up from rodman to draftsman to assistant engineer.

He joined the American Railway Engineering Association in 1954. He was a member of Committee 9–Highways, from 1956 to 1959 and Committee 15–Steel Structures, from 1960 until the time of his death. He was also a member of the Kansas Engineering Association, the Topeka Engineers Club and the Eagles Lodge.

Mr. Rosen is survived by his wife, Dorothy Flanagan Rosen; a sister, Mrs. D. C. Christenson; and his stepfather, George Denton.

Report of Committee 30—Impact and Bridge Stresses



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A. Youhanaie

Committee

(E) Member Emeritus.

Those whose names are shown in boldface, in addition to the chairman and vice chairman, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Steel, Collaborating as Necessary or Desirable with Committee 15.

2. Concrete, Collaborating as Necessary or Desirable with Committee 8.

3. Timber, Collaborating as Necessary or Desirable with Committee 7. No progress to report on Assignments 1, 2, and 3. Funds again were not allocated and research personnel was not available at the AAR Research Center. The committee is now reviewing past research efforts and formulating recommendations for the resumption of structural research and testing.

4. Electronic Computers, Collaborating with Committees 15, 16 and 32. Progress report, presented as information .... page 304

5. Study Leading Toward the Establishment of a Consistent Design Loading for All Structures Supporting Railway Loading, Collaborating as Necessary or Desirable with Committees 1, 7, 8, 14 and 15. Progress report, presented as information .... page 305

The Committee on Impact and Bridge Stresses,
M. Noyszewski, *Chairman*.

Report on Assignment 4

Electronic Computers

E. R. Andrlik *(chairman, subcommittee)*, A. J. S. Carr, J. W. Davidson, E. B. Dobranetski, D. J. Engle, J. A. Erskine, R. J. Fisher, J. F. Hoss, Jr., A. D. M. Lewis, G. F. Leyh, D. F. Lyons, J. F. Marsh, C. H. Newlin, J. A. Peterson, M. Velebit, W. H. Walker, M. E. Weller, E. N. Wilson, D. R. Wright, A. Youhanaie.

Last year's report of this committee (in Bulletin 636, January–February, 1972, page 410) included descriptions of the six AAR computer programs for railway bridges that are available through the AAR Research Center. We have since received information from the AAR Research Center that Program Nos. 1, 2, 4 and 5 have been further revised. For ease of reference the program titles and latest revision dates are listed below. For program descriptions refer to Bulletin 636.

This subcommittee is collecting and evaluating suggestions for further work on these programs and for new programs. The committee is especially seeking feedback from users of the present programs and has distributed a questionnaire primarily to heads of railroad bridge departments. Suggestions for expansion, revision or improvements to these programs and recommendations for additional programs are invited from members of the Association.

AAR Computer Programs for Railway Bridges

Program No. 1—Moment and Shear Tables for Heavy-Duty Cars on Bridges (Revised August 1971).

Program No. 2—Analysis of Railway Truss Bridges (Revised December 1970).

Program No. 3—Analysis of Pratt, Howe and Warren Type Railway Truss Bridges (April 1968).

Program No. 4—Rating of Railway Truss Bridges (Revised December 1970).

Program No. 5—Analysis and Rating of Plate Girder Railway Bridges (Revised March 1970).

Program No. 6—Analysis and Rating of Railway Bridge Floors (December 1970).

Report on Assignment 5

Study Leading Toward the Establishment of a Consistent Design Loading for All Structures Supporting Railway Loading

Collaborating with Committees 1, 7, 8, 14 and 15

D. R. Wright *(chairman, subcommittee)*, E. R. Andrlik, D. S. Bechly, L. N. Bigelow, E. S. Birkenwald, G. F. Dalquist, J. W. Davidson, N. E. Ekrem, J. A. Erskine, K. H. Lenzen, A. D. M. Lewis, G. F. Leyh, C. V. Lund, D. F. Lyons, H. L. Machicao, J. F. Marsh, J. Michalos, W. W. Munse, D. W. Musser, A. L. Piepmeier, M. J. Plumb, C. R. Sanders, W. W. Sanders, Jr., C. B. Smith, H. Solarte, J. D. Tapp, Jr., J. R. Williams.

Last year's report (published as information in Bulletin 636, January–February 1972, pages 412–416) included a draft of specifications for loading railway structures applicable to Chapter 1—Roadway and Ballast, Chapter 7—Timber Structures, Chapter 8—Concrete Structures and Foundations, and Chapter 15—Steel Structures, and indicated that the study would be expanded in 1972 to include Chapter 14—Yards and Terminals, Part 5, which covers track scales.

Committee 14 has undertaken a complete revision of the section on scales, and we have been advised that our recommended specifications for the loading of steel and concrete components would be consistent with their proposed design criteria. However, as the deflection and bearing stresses on concrete are of special concern in the design and performance of track scales, more exacting requirements will be specified for them than are presently provided for in Chapters 8 and 15.

Impact, as covered in Section 3 of the Tentative Loading Specifications, has been a topic of interest in Committees 7, 15 and 30 during 1972. Committee 7 has considered the addition of an impact statement to the loading provisions of Chapter 7. Likewise, Committee 15 has considered and deferred a proposed revision to the impact formulas for steel bridges.

Committee 30 has under study a simplified impact formula for steel bridges which eliminates the roll effect now included as a separate factor in the existing formulas. This formula was developed principally on the basis of the summary of test results and conclusions included in the Committee 30 report published in the AREA Proceedings, Vol. 61, 1960, pages 51–78; and takes into consideration the more recent published reports.

A review of reports of tests made several years ago on concrete bridges is also being undertaken, to study the correlation of impact data on conventional reinforced concrete, prestressed concrete and steel bridges.

It is hoped that impact in concrete and steel bridges, open and ballasted deck, or where the rail is fastened directly to the structure, and for all classes of equipment, may be expressed as varying percentages of the same basic impact formula.

Report of Committee 1—Roadway and Ballast

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E. L. Robinson, *Secretary*

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R. H. Uhrich
M. Van Kuiken
J. L. Vickers
M. E. Vosseller
A. J. Wegmann (E)
R. D. White
R. L. Williams
Committee

(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Roadbed.

   Ballot approval was received to publish, as Manual material, the revised sections of Part 1—Roadbed, dealing with Exploration and Testing, Design and Construction. These sections are presented for adoption in Part 1 of Bulletin 640, November–December 1972. It is proposed that this revision replace the entire present Part 1 of the Manual.

   The subcommittee is proceeding with the preparation of the remaining section of the revision, namely Maintenance. To insure completeness of coverage, the specialized experience of all members of Committee 1 in roadbed maintenance problems will be called upon.

2. Ballast.

   No report.

3. Natural Waterways.
The committee is reviewing Manual material on Prevention of Erosion for possible revision and updating.

4. Culverts and Drainage Pipe.
Progress report submitted as information .... page 308

5. Pipelines.
The growing use of plastic pipe in industry has prompted a study of this material on railway rights-of-way. This committee will assemble pertinent information on this subject and present it for publication as information.

6. Fences.
This committee is completely reassembling the existing information on this subject and will present it in the decimal format.

8. Tunnels.
Brief progress report submitted as information .... page 309

9. Vegetation Control.
Your committee is revamping the presentation of all of the material in Part 9. Updating the section on Terminology is just about complete. Work on the next section, "Planning a Vegetation Control Program," is underway.

The Committee on Roadway and Ballast,
M. B. Hansen, *Chairman.*

Report on Assignment 4

Culverts and Drainage Pipe

W. M. Dowdy *(chairman, subcommittee),* C. W. Bean, R. M. Clementson, G. C. Fenton, J. S. Fluke, R. V. Perrone, J. L. Vickers.

The committee is revising the specifications for the placement of concrete culvert pipe. These specifications are to be included with Committee 1 Manual material with the concurrence of Committee 8. The material on installation of pipe culverts, page 1–4–17, will also be incorporated in this revision.

Last year your committee presented as information preliminary Specifications for Steel Tunnel Liner Plates. These specifications were published in Bulletin 636, January–February 1972, pages 419–426.

In these specifications the table in Art. 4.12.5.4, Joint Strength, on page 423 should be revised to read as follows:

Ultimate design longitudinal seam strengths are:

Plate Thickness In Inches	Ultimate Strength in Kips/Ft 2-Flange	4-Flange
0.075	20.0	. .
0.105	30.0	26.4
0.135	47.0	43.5
0.164	55.0	50.2
0.179	62.0	54.5
0.209	87.0	67.1
0.239	92.0	81.5
0.250		84.1
0.313		115.1
0.375		119.1

Thrust *T* multiplied by the safety factor, should not exceed the ultimate seam strength.

The corrections to the ultimate strength for 4-flange joints as noted above have been established by actual tests.

Report on Assignment 8

Tunnels

J. A. Goforth *(chairman, subcommittee)*, R. D. Baldwin, C. W. Bean, S. F. Burmeister, D. H. Cook, A. P. Crosley, H. E. McQueen, H. E. Richards.

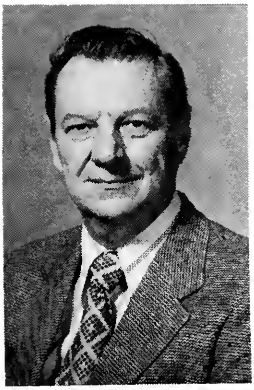
Your committee submits the following report as information:

The problem facing railroads at present with respect to tunnels is not the construction of new tunnels but the job of increasing the clearances in existing tunnels to handle the ever-increasing size of equipment. Our assignment is to develop Manual specifications on methods of increasing clearances.

In attempting to develop the subject it was apparent that conditions are so variable from project to project that no set of fixed specifications can be developed that would be applicable to work that presents such contrasting and varying conditions.

About 1957 the tunnel subcommittee undertook a similar assignment and it was concluded at that time that no report could be developed for the same reason. Since it is not possible to develop fixed specifications to cover the subject we are now considering a different approach; that is, to develop some general guidelines listing conditions to be considered in developing procedural plans for tunnel enlargement work.

Report of Committee 5—Track



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W. J. Wanamaker
I. V. Wiley
M. E. Wilson, Jr.
E. R. Wiltz
A. Wisman
Committee

(E) Member Emeritus.

Those whose names are shown in boldface, in addition to the chairman, vice chairman and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.

No report.

2. Track Tools.

Progress report, submitted as information .... page 313

3. Revision of Portfolio of Trackwork Plans and Specifications, Collaborating as Necessary or Desirable with the AAR Mechanical Division and Communications and Signal Section.

Progress report, submitted as information .... page 313

4. Track Design, Collaborating as Necessary or Desirable with Committees 1, 3 and 4.

(a) Bridge expansion joints—Type, location and necessity.

(b) Tie plates, including pads under plates.
   1. Evaluate canted tie plate design relative to 1:20 cant vs: 1:40 cant vs: 1:14 cant

(c) Hold-Down Fastenings:
   1. Wood ties
   2. Concrete ties

Progress report submitted as information .... page 314

5. Turnout and Crossing Design, Collaborating as Necessary or Desirable with Committees 1, 3 and 4.

   (a) Proper use of various types of crossing frogs as related to speed, tonnage, etc.

   (b) Review taper on guard rails protecting track crossing frogs.

   (c) Improvements to manganese insert frog design.

   Progress report submitted as information .... page 314

6. Track Construction, Collaborating as Necessary or Desirable with Committees 1, 3, 4, and 22.

   (a) Procedure and specifications for, and economies to be derived from, building track by Panel Method:
      1. To remain as paneled after relocation.
      2. To have its joints restaggered after relocation.
      3. Specifications, plans and procedures for prefabricating turnouts in a central shop.
      4. Methods of moving prefabricated turnouts from a central shop to point of use.
      5. Methods of handling a prefabricated turnout at point of renewal or installation.

   Progress report submitted as information .... page 315

7. Track Maintenance, Collaborating as Necessary or Desirable with Committees 1, 3, 4, 22 and 31.

   (b) Modern methods of heat treating carbon steel trackwork and repairing such trackwork by welding.

   No report.

8. Criteria for Track Geometry Design as Related to Modern Equipment, Collaborating as Necessary or Desirable with Other AREA Technical Committees, and with the Engineering, Mechanical and Operating—Transportation Divisions AAR.

   (a) Special requirements of track construction and maintenance due to operation of equipment with high centers of gravity.

   No report.

THE COMMITTEE ON TRACK,
L. A. PELTON, *Chairman.*

Report on Assignment 2

Track Tools

S. W. George *(chairman, subcommittee)*, S. W. Brunner, R. V. Dangremond, G. E. Fischer, C. W. Morrison, T. C. Netherton, J. Payne, B. E. Peterson, L. A. Pelton, G. Perko, E. F. Pittman, B. Post, L. L. Rekuch, A. Wisman.

This is a progress report submitted as information.

Your committee, in continuing its study on frog tongs and frog hooks, has distributed to all of its members a plan prepared through the cooperation of former Subcommittee Chairman T. L. Biggar, C&O—B&O (retired). Comments are being gathered toward making a recommendation to the full committee in the near future.

Study is continuing on suggested modifications to two types of rail anchor wrenches.

Although a tentative conclusion has been reached that "due to the number of railroads which are not fully mechanized, the tools now covered in the Manual should be continued," it is still the opinion of many members that very little, if any, use is presently being made of some of the Manual material on tools. Hence, further study will be given to this matter.

Additional items which will be progressed in the coming year are (1) spalling of spike mauls, sledges, and chisels, which has been the cause of personal injuries on one road, (2) review of claw bar plan following an assertion that many roads are not using the present 1962 plan claw bar but have reverted to using the 1929 plan bar, (3) a review of tool manufacturing tolerances, which some tool suppliers state cannot be obtained, (4) ratchet-type rail fork, (5) review of track jacks, (6) fiber-glass handles, and (7) an examination of use and need for insulated tools in third rail territory.

Report on Assignment 3

Revision of Portfolio of Trackwork Plans and Specifications

R. E. Kuston *(chairman, subcommittee)*, A. G. Ellefson, C. H. Gaut, W. D. Hutchison, R. J. Jones, A. J. Kozak, J. R. Masters, C. J. McConaughy, L. P. McKenna, B. W. Nyland, B. E. Pearson, L. A. Pelton, W. C. Pope, A. C. Trimble.

This is a progress report submitted as information.

Your committee is considering the advisability of updating the whole Portfolio. Each subcommittee member has been assigned a number of plans for review and comment. After collecting and analyzing these comments a recommendation will be made as to the scope and extent of this updating effort.

To be included in this task is the updating of Appendix A to the Portfolio. Especially in need of review are the ASTM specifications and recommendations. This work will be progressed in cooperation with Subcommittee B and with the welcome assistance of several Committee 5 Associate members.

Report on Assignment 4

Track Design

R. N. Schmidt *(chairman, subcommittee)*, S. W. Brunner, M. E. Byrne, D. E. Crouser, R. J. Hardenbergh, A. J. Kozak, B. W. Nyland, B. E. Pearson, L. A. Pelton, W. P. Pope, J. A. Saunders, V. M. Schwing.

(a) Bridge Expansion Joints—Type, Location and Necessity

This subject has not been recently active due to budgetary restrictions at the AAR Laboratory. It is the intent of your committee to (1) review the material and information previously collected, (2) evaluate the present need for additional information and investigation, (3) recommend either continuing or deleting the assignment, and (4) actively progressing the assignment to a conclusion if it is decided additional information and recommendations would still be useful to the railroads.

(b) Tie Plates, Including Pads Under Plates:

1. Evaluate canted tie plate design relative to 1:20 cant vs. 1:40 cant vs. 1:14 cant.

This assignment will continue to be studied. A progress report will be available for the next Track Committee annual report.

(c) Hold-Down Fastenings:

1. Wood ties
2. Concrete ties

Study is continuing on these assignments.

Report on Assignment 5

Turnout and Crossing Design

C. J. McConaughy *(chairman, subcommittee)*, A. G. Ellefson, R. J. Jones, C. N. King, R. E. Kuston, J. R. Masters, L. P. McKenna, B. E. Pearson, L. A. Pelton, G. H. Perkins, George Perko, L. E. Porter, L. L. Rekuch, A. J. Schavet, E. R. Wiltz.

(a) Proper Use of Various Types of Crossing Frogs as Related to Speed, Tonnage, Etc.

From investigation by your committee and data developed, it was considered that Assignment 5 (a) as worded above is impractical to resolve. It was recommended, therefore, to reword the assignment to give data more of an informative nature, leaving the type of crossing to be used to the judgment of the engineer in charge. The new wording is, "Types of Crossing Frogs in Use as Related to Speed, Tonnage, Etc."

Since the Portfolio of Trackwork Plans did not include plans for manganese steel insert crossings in the angle range 90° to 45°, three such plans were developed, one for angles 90° to 70°, incl., another for angles below 70° to 60°, incl., and the third for angles below 60° to 45°, incl. These three plans, along with another plan showing the designs and dimensions of the manganese steel inserts for these crossings, were approved for adoption by letter ballot and were published in Part 1 of Bulletin 640, November–December 1972, for approval by the Board of Direction.

(b) Review Taper on Guard Rails Protecting Track Crossing Frogs

This subject is under study by your committee.

(c) Re-evaluate Explosive Hardening of Frogs to Determine Procedures and Economics

This subject has been completed. Provision for hardening impact areas by explosive hardening, if desired, has been incorporated in Appendix A of the Portfolio of Trackwork Plans.

(d) Improvements to Manganese Steel Insert Frog Design

A new plan, No. 600A-72—Design Criteria for Railbound Manganese Steel Frogs, applicable to all frogs from No. 4 to No. 20, incl., Plans 611 through 615, was approved for adoption by letter ballot and published in Part 1 of Bulletin 640, November–December 1972 for approval by the Board of Direction. This is a revision of old Plan No. 600—Rules for Laying Out Railbound Manganese Steel Frogs adopted in 1928 and at a later date removed from the Portfolio.

A new design of railbound manganese steel frog is under study which eliminates the reverse bends in the wing rails and heel rails, providing an improved casting design and eliminating breakage at the heel end of the castings. Plans of the proposed frog changes have been distributed for the committee's consideration. Several manufacturers are building this type of frog for some railroads. Reports on their performance will be submitted.

Report on Assignment 6

Track Construction

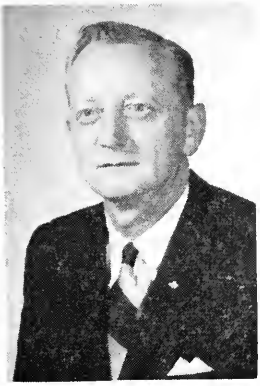
G. E. Fischer *(chairman, subcommittee)*, C. D. Archibald, R. V. Dangremond, D. R. Davis, C. L. Gatton, H. D. Hahn, J. R. Harris, W. D. Hutchison, E. J. Lisy, Jr., A. E. Mooney, B. E. Pearson, L. A. Pelton, E. F. Pittman.

Your committee submits as information the accompanying results of a questionnaire sent to 38 railroads late in 1971 relative to "Panel Track and Panel Turnouts."

1. Extent panels are used:
   (a) 83% of the railroads sampled used panel track and/or turnouts.
   (b) Of those using panel track and turnouts, 96% used track panels and 70% used turnout panels.
   (c) Of those using panels, 59% used track panels and 56% used turnout panels for maintenance purposes.
   (d) Of those using panels, 78% used track panels and 94% used turnout panels for construction purposes.
2. Location where panels are used:
   (a) 41% used track panels and 32% used turnout panels in main line track.
   (b) 55% used track panels and 25% used turnout panels in branch lines.
   (c) 68% used track panels and 81% used turnout panels in yard tracks.
   (d) 59% used track panels and 81% used turnout panels in sidings.
   (e) 59% used track panels and 44% used turnout panels in industry track.
   (f) 87% used track panels and 6% used turnout panels for wreck repairs.
3. Where track panels are built:
   (a) 72% built track panels and 25% built turnout panels at a fixed plant.
   (b) 38% built track panels and 69% built turnout panels at the job sight.

4. Those railroads which purchase their panels:
   5% purchase track panels, and 38% purchase turnout panels.
5. Those railroads which use a template for construction:
   72% used a template to construct track panels, and 50% used a template to construct turnout panels.
6. The equipment used for the handling of track and turnout panels:
   The trend among railroads involved the use of an overhead crane for fixed plant construction and the use of a locomotive crane or crawler crane for construction at the job site.
7. The equipment used for fabricating of track and turnout panels:
   The majority of the railroads used the same basic equipment in fabricating. This included small crane, air compressor, spike drivers, saw and drill, power wrench, anchor machine, and tie handler. Some railroads use the panel lifter for handling completed panels.
8. Labor used for construction:
   Labor forces for general construction varied considerably, but an average did show about a 7 to 8 man gang is used for panel construction of track and turnouts.
9. Sizes of turnouts paneled:
   All sizes of turnouts up to No. 20 were prefabricated but the most common size varied between No. 6 and No. 10.
10. Equipment used to transport track panels:
    (a) 84% used standard gondolas.
    (b) 26% used standard flat cars.
    (c) 26% used special cars.
    (d) 16% used flat trailers.
11. Equipment used to transport turnout panels:
    (a) 56% used standard gondolas.
    (b) 34% used standard flat cars.
    (c) 33% used special cars.
    (d) 22% used flat bed trailers.
    Note: Only 56% of those using turnout panels transport them.
12. The method of removing old track:
    (a) 74% dismantle track and 63% dismantle turnouts.
    (b) 26% panelize track and 37% panelize turnout.
13. Location where paneled joints are staggered:
    (a) Main line tangents and curves, 100%.
    (b) Branch line tangents, 84%; branch line curves, 81%.
    (c) Yard tangents, 7%; yard curves, 25%.
    (d) Siding tangents, 15%; siding curves, 38%.
    (e) Industry tangents, 0%; industry curves, 31%.
14. The type of ties used:
    (a) For track panels, 60% used all new ties, and 40% used new and secondhand ties.
    (b) For paneled turnouts, 87% used all new ties and 13% used new and secondhand ties.
15. Anchoring and spiking of panels:
    There is considerable variation among the railroads using panels in the area of anchors and spikes. No definite conclusions can be reached in this area.

Report of Committee 4—Rail



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R. M. **Brown**, *Vice Chairman*

A. B. **Merritt, Jr.**, *Secretary*

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John H. Watts
C. E. Weller
D. J. White
H. M. Williamson

Committee

(E) Member Emeritus.

Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association

Your committee reports on the following subjects:

B. Revision of Manual.

Progress report, presented as information .... page 318

2. Collaborate with AISI Technical Committee on Rail and Joint Bars in Research and Other Matters of Mutual Interest.

Part 1—Visit to a Rail Producing Mill and the Department of Transportation High Speed Ground Test Center, progress report, presented as information .... page 319

Part 2—Study the Subject of Obtaining Rails Longer Than 39 ft., Looking to Developing the Optimum Length of Rail That Will Be Acceptable, Based on Handling Methods, Supply of Cars, the Number of Rails Which Can Be Obtained from Steel Company Ingot Molds, and Other Necessary Considerations, progress report, presented as information .... page 320

Part 3—Other Collaboration with American Iron and Steel Institute Technical Committee on Rail and Joint Bars, progress report, presented as information .... page 327

3. Rail Failure Statistics, Covering (a) All Failures; (b) Transverse Fissures; (c) Performance of Control-Cooled Rail.
Final report, presented as information .... page 328

4. Rail End Batter; Causes and Remedies.
No report.

5. Rail Chemistry.
Progress report, presented as information .... page 328

6. Joint Bars: Design, Specifications, Service Tests, Including Insulated Joints and Compromise Joints.
Progress report, presented as information .... page 332

7. Metallurgical Effect of Rail Cropping Methods.
Final report, presented as information .... page 333

8. Causes of Shelly Spots and Head Checks in Rail; Methods for Their Prevention.
No report.

9. Standardization of Rail Sections.
Progress report, presented as information .... page 335

10. Effect of Heavy Wheel Loads on Rail.
No report.

The Committee on Rail,
V. E. Hall, *Chairman.*

Report on Assignment B

Revision of Manual

R. M. Brown *(chairman, subcommittee)*, R. E. Catlett, Jr., J. T. Collinson, R. G. Garland, V. E. Hall, A. V. Johnston, R. R. Lawton, A. B. Merritt, Jr., J. B. Miller, R. B. Rhode, C. E. Weller, H. M. Williamson.

The special committee consisting of W. J. Cruse (chairman), E. T. Franzen and V. E. Hall whose assignment is to progress the updating and rewriting of the remainder of Manual Chapter 4—Rail, held no formal meetings during 1972 but have maintained contact with the AISI Technical Committee on Rail and Joint Bars, actively participated in the work of Subcommittee 5—Rail Chemistry, and the Ad Hoc Committee on Rail Welding Problems as these assignments may indicate a need for Manual revisions.

The Ad Hoc Committee on Rail Welding Problems formed in 1971 to investigate the problems relating to rail straightness, twist and end conditions as they affect the rail welding process continued its efforts. A small group from the Ad Hoc Committee consisting of representation from the AISI technical group, rail welding contractors, AREA Committee 31 and AREA Committee 4 held two meetings during 1972, one in Chicago on March 21 and the other at U.S. Steel's plant at Gary on October 12. The meeting at Gary included inspection of rails as they were taken from the cooling boxes, rail straightening area and the final inspection beds. We expect to finalize this assignment during 1973 and present proposed revisions to Section 12—Workmanship, of the rail specifications.

Report on Assignment 2

Collaborate with AISI Technical Committee on Rail and Joint Bars in Research and Other Matters of Mutual Interest

V. E. Hall, *(chairman, subcommittee)*, J. I. Adams, B. G. Anderson, R. M. Brown, R. E. Catlett, Jr., J. T. Collinson, W. J. Cruse, E. T. Franzen, W. H. Freeman, C. C. Herrick, T. B. Hutcheson, K. H. Kannowski, W. S. Lovelace, A. B. Merritt, Jr., R. B. Rhode, W. A. Smith, E. H. Waring, H. M. Williamson.

Your committee presents its report on Assignment 2 in three Parts. Part 1, immediately following, covers the Rail Committee's visit to the mill of the CF&I Steel Corporation in furtherance of its practice of visiting rail production facilities of major steel companies, also our visit to the DOT High Speed Ground Test Center.

Part 2, beginning on page 320, is a report on the committee's assignment to "Study the subject of obtaining rails longer than 39 ft. looking to developing the optimum length of rail that will be acceptable, based on handling methods, supply of cars for shipping, the number of rails which can be obtained from ingot molds and other necessary considerations"

Part 3, beginning on page 327, discusses other collaboration with the American Iron and Steel Institute Technical Committee on Rail and Joint Bars undertaken during 1972.

PART 1

VISIT TO A RAIL PRODUCING MILL AND THE DEPARTMENT OF TRANSPORTATION HIGH SPEED GROUND TEST CENTER

During 1972 the Rail Committee continued its plan of visiting rail production facilities of major steel companies. These visits, which are considered very educational for our committee, are conducted under arrangements made by the Joint Contact Committee with the American Iron and Steel Institute Technical Committee on Rail and Joint Bars. A visit to the mill of the CF&I Steel Corporation, and the DOT High Speed Ground Test Center in conjunction with a regular business meeting were scheduled for May 2–3, 1972 at Pueblo, Colo.

The visit to the CF&I mill was made on the morning of May 2. Our committee was conducted on a very informative tour of the company's basic oxygen steel making facilities where we observed a complete cycle of one vessel. This was followed by a visit to the rail rolling and finishing areas of the mill. At the rail inspection area we observed ultrasonic testing of rail ends by Union Pacific's rail inspectors.

The visit to the DOT High Speed Ground Test Center was made on the afternoon of May 2. Following an interesting briefing by members of the DOT Test Center staff, we visited the service building for the LIM Test Vehicle where we were briefed and permitted to inspect the experimental LIM Test Vehicle and its trackage. A demonstration run of the vehicle had been planned, but was cancelled due to mechanical difficulties.

The committee wishes to acknowledge its grateful appreciation to the AISI Technical Committee on Rail and Joint Bars for arranging the visits to the CF&I mill and the DOT Test Center. The committee extends its sincere thanks to the CF&I Steel Corporation for its hospitality during our stay in Pueblo.

PART 2 (REPORT ON ASSIGNMENT 2 (a)

STUDY THE SUBJECT OF OBTAINING RAILS LONGER THAN 39 FT. LOOKING TO DEVELOPING THE OPTIMUM LENGTH OF RAIL THAT WILL BE ACCEPTABLE, BASED ON HANDLING METHODS, SUPPLY OF CARS FOR SHIPPING, THE NUMBER OF RAILS WHICH CAN BE OBTAINED FROM INGOT MOLDS AND OTHER NECESSARY CONSIDERATIONS

This subject was assigned in 1968 and discussions were held with the steel industry members of the Joint Contact Committee, which is composed of representatives of Subcommittee 2 and of the American Iron and Steel Institute Technical Committee on Rail and Joint Bars. The AISI members indicated that any appreciable increase in length of rail over 39 ft would require the solution of many problems, including those of handling, control-cooling and straightening, requiring substantial and costly plant revisions. They agreed to progress solution of those problems, if they could be given some assurance that there was a strong demand for longer rail.

Subcommittee 2 made a study in 1969 to develop data on the demand for longer rail but it was discarded because it included rail purchased for all purposes. A new questionnaire was prepared and sent to the chief engineers of the 77 AAR Member Roads in November 1970 and responses were received from 40 railroads. A very complete report on this assignment along with a tabulation of the responses to the November 1970 questionnaire appears on pages 279 to 285, inclusive, of the January–February 1972 AREA Bulletin, No. 636.

At our committee meeting in Pueblo on May 3, 1972, it was decided that this subject should be further progressed by preparing and sending out another questionnaire in an effort to update and correct data previously furnished and hopefully to secure permission to use each railroad's name in the summary to be prepared from replies. The new questionnaire was sent out July 25, 1972, to 75 AAR Member Roads and responses were received from 43 railroads or 57.3% of those sent the questionnaire. The following information was requested by years for 1966 to 1970, inclusive:

1. If the rail mills would offer rails of 117′ lengths, 78′ lengths, and 39′ lengths, we would specify in our order that ....% of the rails be 117′ long, ...% of the rails be 78′ long, and ....% of the rails be 39′ long.

2. If the mills would offer rails of 78′ lengths and 39′ lengths, we would specify in our order that ....% of the rails be 78′ long and ....% of the rails be 39′ long.

3. Rail Purchased—Net Tons:

Year	*For Welding into CWR*	*39′ Jointed Rails for Construction, Maintenance and Other Uses*
1966	....	....
1967	....	....
1968	....	....
1969	....	....
1970	....	....

4. Information may be released by road name through AREA–AISI Joint Contact Committee:

Yes No

5. Would your railroad be able to furnish cars to handle rails of 78-ft as a single-car load?

Of the 43 railroads that returned completed questionnaires 4 roads asked that the information they furnished not be released by road name and such roads are designated by number in Table 1.

It is to be noted from the data in Table 1 that a strong interest is indicated for rails longer than 39 ft. For the five years included in this study, representing 55.6% of the average tonnages rolled in those years, the reporting roads indicate that, if given a choice of 117-ft, 78-ft, and 39-ft rails, 36% would have been purchased in 117-ft lengths, 48% in 78-ft lengths, and 16% in 39-ft lengths. If offered only 78-ft and 39-ft lengths, 84% of the rail purchased by reporting roads would have been in 78 ft lengths and 16% in 39-ft lengths.

It will also be noted from Table 1 that only 10 of the 43 responding railroads indicated they could provide cars to handle 78-ft rails as a single-car load. Also, that two railroads indicated "Information not available" in response to the questions on percentages of rail of various lengths they would order and that another large road indicated they would order 100% of their rail requirements in 39-ft lengths. In discussing this with representatives of those three railroads it was determined they could not make such a decision until they know what, if any, increase in cost might be applied to rails longer than 39-ft.

Some of the economic factors that must be considered by railroads desiring rails longer than 39 ft are:

1. That the use of rails longer than 39 ft will require a considerable number of changes in the present methods of rail handling and storage at welding plants, as most facilities are geared to 39-ft rails.
2. That no car supply, as such, is presently available on a national basis.
3. Any increase in cost that might be applied by the mills to rails longer than 39 ft.

Due to the need to restrict car lengths to the general area of 89 ft to avoid the turnout and curve negotiation problems inherent in longer cars, it will not be practical to make a one-car load of 117-ft rails. We are unable to suggest an exact length of rail for welding but last July asked AREA Committee 31—Continuous Welded Rail, to develop what the optimum length of rails should be insofar as welding plant operations are concerned. The car length restriction referred to above requires that any rail longer than about 85 ft would have to be handled as a two-car load to avoid turnout and curve restrictions and the costs associated with such handling may well adversely affect the economics of purchasing rail of lengths in excess of single-car loads.

The data compiled, which has been furnished to the AISI Technical Committee on Rails and Joint Bars, definitely indicates a strong desire for rails longer than 39 ft and that a 78-ft length was acceptable to 84% of the respondents. Our committee feels we have fulfilled the AISI members request for assurance that a strong demand for longer rail does exist and that they should now progress solution of mill problems involved with furnishing longer rails and report back to our committee as soon as possible.

This report is submitted as information with the recommendation that the study be continued with the AISI Technical Committee so the possibility of plants furnishing rails longer than 39 ft can be resolved at an early date.

TABLE 1

Sheet 1 of 4

SUMMARY OF RAIL LENGTH STUDY

AREA COMMITTEE 4 - RAIL

Railroad	Cars to Handle 78 ft.	Rail Use	Net Tons Rail Purchased 1966	1967	1968	1969	1970	1966-70 Average Net Tons	Question No. 1: 117 ft. %	117 ft. Tons	78 ft. %	78 ft. Tons	39 ft. %	39 ft. Tons	Question No. 2: 78 ft. %	78 ft. Tons	39 ft. %	39 ft. Tons
Algoma Central Ry.	No	CWR	0	0	0	0	0	0					100	0			100	0
		Other	880	880	880	880	880	880										
Atchison, Topeka & Santa Fe Ry.	No	CWR	47,736	34,275	50,168	56,748	58,498	49,485	100	49,485					100	49,485		
		Other	1,476	1,058	1,552	1,755	1,809	1,530										
Bangor & Aroostook RR.	No	CWR	0	0	0	0	0	0	90	0			10	0	90	0	10	0
		Other	626	44	566	277	867	476										
Belt Ry. Co. of Chicago	No	CWR	0	0	0	0	0	0	90	0			10	0	90	0	10	0
		Other	1,102	1,467	0	0	814	677										
Bessemer & Lake Erie RR.	No	CWR	1,529	2,772	869	2,465	1,750	1,877			85	1,595	15	282	85	1,595	15	282
		Other	0	0	0	0	70	14										
Boston & Maine Corporation	No	CWR	0	0	0	0	0	0			95	0	5	0	95	0	5	0
		Other	0	0	0	0	1,100	220										
Burlington Northern	No	CWR	34,837	61,017	19,588	31,927	33,315	36,137			95	34,330	5	1,807	95	34,330	5	1,807
		Other	5,454	7,524	5,286	5,404	6,328	5,999										
Canadian National Rys.	Yes	CWR	47,319	31,828	52,801	109,010	143,190	76,830			75	57,623	25	19,207	75	57,623	25	19,207
		Other	44,613	92,579	71,349	47,864	31,406	57,562										
Chesapeake & Ohio Ry/ Baltimore & Ohio RR.	No	CWR	38,000	36,000	39,000	24,000	35,000	34,400					100	34,400			100	34,400
		Other	0	0	0	0	0	0										
Chicago & North Western Transportation Company	Yes	CWR	1,390	7,680	4,154	6,437	2,026	4,337	2.7	117	81.7	3,543	15.6	677	83.5	3,621	16.5	716
		Other	520	2,320	926	1,663	3,644	1,815										
Chicago, Milwaukee, St. Paul & Pacific RR.	No	CWR	0	0	0	0	0	0	90	0	6	0	4	0	96	0	4	0
		Other	10,200	9,356	4,400	10,656	8,211	8,565										
Chicago, Rock Island & Pacific RR.	Yes	CWR	11,548	5,823	0	4,187	4,990	5,310	100	5,310					100	5,310		
		Other	0	0	0	0	0	0										

TABLE 1 (Continued)

Sheet 2 of 4

Railroad	Cars to Handle 78 ft.	Rail Use	Net Tons Rail Purchased 1966	1967	1968	1969	1970	1966-70 Average Net Tons	Question No. 1 117 ft. %	Tons	78 ft. %	Tons	39 ft. %	Tons	Question No. 2 78 ft. %	Tons	39 ft. %	Tons
Clinchfield RR.	No	CWR	4,800	2,500	2,500	2,200	2,350	2,870	90	2,583			10	287	90	2,583	10	287
		Other	1,160	1,160	1,160	1,800	0	1,056										
Delaware & Hudson Ry.	No	CWR	0	1,388	5,382	0	0	1,354	100	1,354					100	1,354		
		Other	0	0	0	0	0	0										
Denver & Rio Grande Western RR.	Yes	CWR	0	8,200	5,400	6,700	0	4,060			75	3,045	25	1,015	75	3,045	25	1,015
		Other	3,500	2,900	830	3,100	3,100	2,686										
Detroit & Toledo Shore Line RR.	No	CWR	0	0	0	0	0	0			70	0	30	0	70	0	30	0
		Other	0	450	0	0	0	90										
Duluth, Missabe and Iron Range Ry.	No	CWR	1,098	3,349	7,432	117	0	2,399	90	2,159			10	240	90	2,159	10	240
		Other	368	489	1,079	920	1,237	819										
Erie Lackawanna Ry.	Yes	CWR	6,000	10,830	3,530	6,535	0	5,379	78	4,196	18	968	4	215	96	5,164	4	215
		Other	0	1,170	2,470	1,835	0	1,095										
Grand Trunk Western RR.	No	CWR	0	0	0	0	4,390	878	85	746	5	44	10	88	90	790	10	88
		Other	3,885	3,219	2,253	1,704	3,795	2,971										
Maine Central RR.	No	CWR	0	0	0	0	0	0					100	0			100	0
		Other	500	0	0	1,012	1,432	589										
#1	No	CWR	0	0	0	0	0	0					100	0			100	0
		Other	0	100	0	200	100	80										
#2	No	CWR	3,137	2,598	0	0	0	1,147	10	115	75	860	15	172	65	746	35	401
		Other	184	563	0	1,422	0	434										
Missouri Pacific RR.	No	CWR	39,546	36,510	37,395	46,768	36,305	39,305	Information not available									
		Other	1,847	2,510	4,495	1,432	0	2,057										

Table 1 (Continued)

Sheet 3 of 4

Railroad	Cars to Handle 78 ft.	Rail Use	Net Tons Rail Purchased 1966	1967	1968	1969	1970	1966-70 Average Net Tons	Question No. 1: 117 ft. %	117 ft. Tons	78 ft. %	78 ft. Tons	39 ft. %	39 ft. Tons	Question No. 2: 78 ft. %	78 ft. Tons	39 ft. %	39 ft. Tons
Norfolk & Western Ry.	No	CWR	21,000	7,000	13,000	38,596	36,248	23,169	100	23,169					100	23,169		
		Other	0	0	0	0	0	0										
Ontario Northland Ry.	No	CWR	0	0	0	0	0	0			100	0			100	0		
		Other	6,159	4,940	5,347	303	2,919	3,934										
Penn Central Transportation Co.	Yes	CWR	40,200	47,100	44,600	37,600	45,450	42,990	98	42,130			2	860	98	42,130	2	860
		Other	14,000	0	0	0	1,050	3,010										
Peoria & Pekin Union Ry.	No	CWR	0	0	0	0	0	0					100	0			100	0
		Other	100	100	100	100	100	100										
#3	Yes	CWR	0	0	0	0	0	0	10	0	70	0	20	0	80	0	20	0
		Other	3,872	4,526	3,875	3,912	4,136	4,064										
Pittsburg & Lake Erie RR.	No	CWR	1,200	0	3,200	1,550	2,700	1,730	100	1,730					100	1,730		
		Other	0	0	0	0	0	0										
Reading Company	No	CWR	1,185	3,700	3,744	3,712	1,703	2,809	Information not available									
		Other	115	0	256	288	297	191										
Richmond, Fredericksburg & Potomac RR.	No	CWR	0	500	0	0	500	200			5	10	95	190	5	10	95	190
		Other	0	0	0	0	0	0										
St. Louis - San Francisco Ry.	Yes	CWR	14,104	15,778	14,954	12,427	16,788	14,810	90	13,329			10	1,481	90	13,329	10	1,481
		Other	0	0	0	0	0	0										
Seaboard Coast Line RR.	No	CWR	25,712	21,602	23,061	23,181	15,355	21,782			100	21,782			100	21,782		
		Other	0	0	0	0	0	0										
Soo Line RR.	Yes	CWR	2,120	2,690	3,650	3,680	6,360	3,700	95	3,515			5	185	95	3,515	5	185
		Other	0	0	0	0	0	0										
Southern Pacific Transportation Co.	No	CWR	54,586	21,985	41,295	25,834	31,704	35,081			95	33,327	5	1,754	95	33,327	5	1,754
		Other	6,165	2,614	5,226	4,407	N/A	3,682										

TABLE 1 (Continued)

Sheet 4 of 4

Railroad	Cars to Handle 78ft.	Rail Use	Net Tons Rail Purchased 1966	1967	1968	1969	1970	1966-70 Average Net Tons	Question No. 1 117 ft. %	Tons	78 ft. %	Tons	39 ft. %	Tons	Question No. 2 78 ft. %	Tons	39 ft. %	Tons
Terminal RR Assoc. of St. Louis	No	CWR	0	0	0	0	0	0	90	0			10	0	90	0	10	0
		Other	266	252	706	865	561	530										
Texas Mexican Ry.	No	CWR	0	0	0	0	0	0					100	0			100	0
		Other	0	1,000	1,000	2,100	2,000	1,220										
AL	No	CWR	0	0	0	1,953	0	391			20	78	80	313	20	78	80	313
		Other	0	100	0	0	0	20										
Toledo Terminal RR.	No	CWR	280	300	300	328	146	271	100	271					100	271		
		Other	0	0	0	0	23	5										
Union Pacific RR.	Yes	CWR	67,000	23,000	34,600	47,500	37,200	41,860			95	39,767	5	2,093	95	39,767	5	2,093
		Other	22,417	7,848	11,535	15,032	9,555	13,277										
Union RR.	No	CWR	0	0	0	0	0	0	50	0			50	0	50	0	50	0
		Other	1,193	786	1,275	1,357	703	1,063										
Western Maryland Ry.	No	CWR	1,150	2,600	2,600	2,000	1,200	1,910			75	1,433	25	477	75	1,433	25	477
		Other	1,850	0	400	1,000	1,018	854										
Western Pacific RR.	No	CWR	2,771	4,090	0	7,229	0	2,818	60	1,691	30	845	10	282	90	2,536	10	282
		Other	518	775	1,450	1,587	0	866										
Tons Reported		CWR	468,248	395,115	413,223	502,684	517,168	459,289	36	151,900	48	199,250	16	66,025	84	350,882	16	66,293
		Other	132,970	150,730	128,416	112,875	87,155	122,431										
Total Reported			601,218	545,845	541,639	615,559	604,323	581,720										
Total Tons Rolled			1,031,001	897,744	1,016,201	1,111,874	1,177,572	1,046,878										
Per Cent Total Reported to Total Rolled			58.3	60.8	53.3	55.4	51.3	55.6										

PART 3

OTHER COLLABORATION WITH THE AMERICAN IRON AND STEEL INSTITUTE TECHNICAL COMMITTEE ON RAILS AND JOINT BARS

Subcommittee 2 has maintained contact with the AISI Technical Committee during 1972 through its representation on the Ad Hoc Committee on Rail Welding Problems as discussed in the Report on Assignment B; through correspondence with its chairman, G. G. Knupp, assistant metallurgical engineer, Bethlehem Steel Corporation, on updating and rewriting our rail specifications and about progressing specifications for fully-heat-treated rail and rail surface hardened by other processes; their representation on the AAR Ad Hoc Committee on Cooperative Rail Research which also has representatives serving with this group from Subcommittee 5; and through a joint session with the entire committee during our May meeting in Pueblo, Colo.

In addition, the AREA–AISI Joint Contact Committee held meetings at Atlanta, Ga., on October 5–6, 1972, which was the first formal meeting of this group since an abbreviated meeting held in October 1969. Our discussions delved into numerous rail matters such as, rail investigations proposed and underway, specification changes, test installations, rail failures, and rail quality considerations. The minutes of these meetings, which are 10 pages long, have been furnished all members of Committee 4 and all concerned are urged to review this report, which is very complete and informative.

The next Joint Contact Committee meeting is presently scheduled to be held at Sydney, Nova Scotia, in June 1973 to visit the Sysco Rail Mill which is the newest mill that could furnish rail to American railroads. We understand this mill intends to furnish rail longer than 39 ft, and will utilize or are utilizing a roller straightening machine to straighten rail.

The AISI Committee group is scheduled to make an educational presentation at our next Rail Committee meeting, which is scheduled for April 11–12, 1973 at the AAR Research Center, and April 11 is being allocated to the AISI group. Their presentation will include vacuum degassing of rail steel, rail from strand cast blooms, open-top versus hot-topped ingots, ultrasonic inspection of rail at mills, high-strength alloy steels and possibly other items of mutual interest.

Report on Assignment 3

Rail Failure Statistics, Covering (a) All Failures; (b) Transverse Fissures; (c) Performance of Control-Cooled Rail

R. F. Bush *(chairman, subcommittee)*, B. G. Anderson, S. H. Barlow, R. M. Brown, R. D. Claborn, L. S. Crane, Emil Eskengren, R. G. Garland, R. E. Gorsuch, V. E. Hall, C. E. R. Haight, T. B. Hutcheson, A. V. Johnston, J. F. Lyle, A. B. Merritt, Jr., C. F. Parvin, W. A. Smith, Emil Skaks, G. S. Triebel.

Subcommittee 3 submits the following as its final report:

At the Rail Committee meeting held in Chicago on November 9, 1972, considerable discussion was generated about the data previously compiled by personnel at the AAR Research Center from reports submitted by AAR Member Roads on a voluntary basis. It was determined that the AAR had decided to discontinue compiling the data as its costs to do so could not be justified due to the very limited value of the resulting information. It was also determined that most railroads found such reports of little or no value on their individual properties. As a result, the members present at that meeting voted unanimously to eliminate Rail Failure Report Forms 402B, 402C, 402E, 402L, 402M and 402C(a), pages 4–3–8.1 to 4–3–12.1, inclusive, in Chapter 4—Rail, of the AREA Manual.

The AAR Research Center will develop any data required in its rail studies by directly contacting various railroads on an individual basis.

This final report is submitted as information.

Report on Assignment 5

Rail Chemistry

W. J. Cruse *(chairman, subcommittee)*, B. G. Anderson, R. M. Brown, E. T. Franzen, R. E. Gorsuch, R. E. Haacke, V. E. Hall, W. H. Huffman, T. B. Hutcheson, K. H. Kannowski, W. S. Lovelace, A. B. Merritt, Jr., C. O. Penney, F. W. Potter, I. A. Reiner, W. A. Smith.

The assignment of Subcommittee 5—Rail Chemistry, is to review the present specification for rail chemistry and recommend any change in the chemistry which would improve the service life of rail. We have reviewed the experimental work which has been done in the past and which may presently be under test for improved rail chemistry. This includes work done at the AAR Research Center, the University of Illinois, the rail mills (AISI Technical Group) and by various railroads.

The following is a brief summary of the rail–steel chemistry review of laboratory and field service tests:

RAIL STEEL CHEMISTRY REVIEW—LABORATORY AND FIELD SERVICE TESTS OF ALLOY AND HEAT-TREATED RAIL

First reporting of laboratory tests (early rolling-load tests at University of Illinois) from 1943 to the early 1950's: Test results show that, with regard to resistance to rail crushing and wear and shelling, heat-treated standard carbon rail rated best, 3% chromium rail was second, control-cooled intermediate manganese rail was third and standard carbon rail with 0.29% or 0.17% silicon was fourth. Later tests showed heat-treated low alloy rail gave good results.

Early test on Norfolk & Western Railway showed high carbon rail (0.84% to 0.91% C) retarded shelling but had more tendency to head checking and gage corner flaking.

The following is a brief summary of field installations (some correlated with laboratory investigations):

Chesapeake & Ohio Railroad

132-lb RE heat-treated, installed May 1949 at Martha, W. Va.

First inspection report, Proceedings Vol. 52.

Last inspection report, Vol. 68. Rails transposed at 325 MGT, rails in fair condition, last reporting.

Pennsylvania Railroad

155 PS heat-treated, installed January 1949 at Forge, Pa.

First inspection report, Proceedings Vol. 52.

Final inspection report, Vol. 60. Heat treated rail at this location gave 50% additional life over non-heat-treated rail.

155 PS high-silicon, installed October 1953 at Lewiston, Pa.

First inspection report, Proceedings Vol. 57.

Last inspection report, Vol. 68. As of November 1965 with 408 MGT there was no shelling.

140 PS chrome–vanadium, installed October 1955 at Torrence Pa.

First inspection report, Proceedings Vol. 58.

Final inspection report, Vol. 62, as of October 1959: This Cr–Va rail is unreliable. It has good wearing qualities, superior resistance to shelling, but poor resistance to impact; rail end fractures at joints. Same experience reported by N&W Ry. (Same heat of rail.)

140 RE high-silicon, installed June 1956 near Mifflin, Pa.

First report, Proceedings Vol. 59.

Last inspection report, Vol. 68. As of inspection of November 1965 with 338 MGT there was no shelling of the rail.

140 RE high carbon (0.79%/0.92%), installed May 1963 at York Haven, Pa.

First report, Proceedings Vol. 66.

Last inspection report, Vol. 68. As of the inspection of November 1965 there was less curve wear on these rails.

New York Central Railroad

127 Dudley heat-treated and chromium–vanadium installed July 1950 at Cedar Run, Pa.

First report, Proceedings Vol. 59.

Final inspection report, Vol. 62. Rails curve worn after 179 MGT. Both types of rail resisted shelling.

Norfolk & Western Railway

132 RE heat-treated, installed May 1949 at Kermit, W. Va.

First inspection report, Proceedings Vol. 52.

Final inspection report, Vol. 64. Rails on high side of curve removed after 11 years service, 449.6 MGT. Low rails on curve remaining and at 13 years service and 500 MGT are still good and outlasted fifth set of standard carbon rails. Service ratio of 6 to 1.

132 RE heat-treated, installed August 1954 at Maher, W. Va.

First inspection report, Proceedings Vol. 57.

Final inspection report, Vol. 68. Rails transposed at 168.9 MGT in 1959 and in May 1966 after 494.4 MGT had given 5 to 1 service ratio.

132 RE heat-treated, installed August 1954 at Looney's Curve, W. Va.

First inspection report, Proceedings Vol. 57.

Final inspection report, Vol 68. Rails on high side of curve replaced in September 1961, gave service ratio of 5 to 1. Rails on low side of curve still in service in May 1966 after 281 MGT with service ratio of 16 to 1.

132 RE full heat-treated and curvemaster, installed 1964 at Bluefield, W. Va.

First inspection report, Proceedings Vol. 68.

No other reports.

132 RE chrome–vanadium, installed December 1950 on Sciota Division

First inspection report, Proceedings Vol. 54.

Second inspection report, Vol. 55. High-side rails flaking and showing black spots; low-side rails good.

No other reports.

Duluth, Missabe & Iron Range Railroad

115 RE chrome–vanadium, installed March 1954 at Proctor Hill, Minn. and Two Harbors, Minn.

First inspection report, Proceedings Vol. 57.

Report, in Vol. 64, last report, rails still in and in good condition. No further reporting.

Denver & Rio Grande Western Railroad

133 RE Hi-Si installed May 1951 in Glenwood Canyon

First inspection report, Vol. 57. No shelling and less curve wear than standard rail (88 MGT).

No further reporting.

Great Northern Railway

115 RE heat-treated, installed February 1951 at Carlton, Minn.

First inspection report, Proceedings Vol. 53.

Last inspection report, Vol. 68. In May 1961 rails were transposed, 384 MGT and in 1968 with 526.5 MGT shelling was developing.

115 RE Hi-Si, installed June and September 1955 on Cascade and Kalispell Division

First inspection report, Proceedings Vol. 58.

Last report, Vol. 71. Last inspection made in 1969, rails then had 148.5 MGT.

115 RE Columbium treated, installed May 1960 at Carlton, Minn.
First report, Proceedings Vol. 63.
Last report, Vol. 65, rail in good condition.

115 RE Columbium treated, installed May 1961, M.P. 34.
First report, Proceedings Vol. 68—inspected May 1966 with 91 MGT.
Last report, Vol. 69, rails shelling, all but one rail removed.

115 RE heat-treated and curvemaster, installed September 1964 near Nimrod and Blacktail, Mont.
First inspection report, Proceedings Vol. 68.
Latest inspection report, Vol. 71. Last inspection in September 1969, test continuing.

SOUTHERN PACIFIC COMPANY

136 CF&I chrome–vanadium, installed 1957 near Bakersfield, Calif.
First report, Proceedings Vol. 60.
Last report, Vol. 65.

136 CF&I Hi-Si, chrome-vanadium, installed near Bakersfield, Calif.
Reported in Vol. 65. No justification for Hi-Si-Va and Hi-Si-Cr-Va over Hi-Si rail. All tested at same location and all had same curve wear but no shelling.

ADDITIONAL PRESENT DAY TESTS WHICH HAVE BEEN BROUGHT TO OUR ATTENTION:
Tests of fully heat-treated rail and variations of curvemaster rail on the Louisville and Nashville.
Tests of chrome rail on the Canadian Pacific.
Tests of chrome rail on the Canadian National.
Tests of intermediate manganese rail on the Illinois Central Gulf.

It will be noted that a large number of the early tests, which included heated-rail, high-silicon rail, chrome-vanadium rail and columbium-treated rail have either been phased out due to service condition, early shelling, lack of improvement in the wear quality, etc. Curtailment of the AAR Research Center budget in recent years has stopped field inspection by the research staff.

On November 4, 1971, Dr. W. J. Harris, Jr., vice president of AAR Research and Test Department, advised that the AAR Research Center would reactivate the field inspections and laboratory investigations of rail unconventionally produced and currently in track on various railroads. This work is currently in progress under the direction of K. W. Schoeneberg, executive research engineer at the AAR Research Center.

This subcommittee is represented on the Ad-Hoc committee set up by Dr. Harris to explore the possibilities of a joint research effort on rails and associated problems as initiated by the AAR Research and Test Department.

Report on Assignment 6

Joint Bars: Design, Specifications, Service Tests, Including Insulated Joints and Compromise Joints

W. S. Lovelace *(chairman, subcommittee)*, J. I. Adams, R. M. Brown, R. E. Catlett, G. P. Chandler, R. D. Claborn, P. K. Cruckshank, Emil Eskengren, V. E. Hall, W. T. Hammond, K. H. Kannowski, A. B. Merritt, Jr., R. H. Patterson, I. A. Reiner, D. H. Shoemaker, B. D. Sorrels, C. L. Stanford, D. J. White, H. M. Williamson.

SERVICE TEST OF EPOXY BONDED NON-INSULATED JOINTS ADJACENT TO TRACKWORK

Southern Railway installed 12 non-insulated joints adjacent to frogs and turnouts in August 1972 in an effort to evaluate potential benefits of eliminating bolted joints adjacent to trackwork and to evaluate service life of epoxy-bonded non-insulated joints. These test joints will be inspected periodically and results reported to the committee at a later date.

SERVICE TEST OF EPOXY-BONDED INSULATED JOINTS

Epoxy-bonded insulated joints manufactured by Allegheny, Portec and I-Bond are presently under test in main-line track on Southern. These joints have service experience ranging from three months to four years. Also included in these tests is a comparison of using heat-treated vs. control-cooled rail for fabrication of epoxy-bonded joints. Another study is included to determine merits of ⅜-inch vs. 5/32-inch rail end gaps as a deterrent to rail end batter. The above installations will continue to be inspected periodically and results reported to committee at the appropriate time.

CAST VS. WROUGHT COMPROMISE JOINTS

The subcommittee is considering an additional assignment to write specifications and recommendations for cast vs. wrought compromise joints. Industry-wide failure statistics will be compiled to establish the need for new specifications.

STRENGTH CONSIDERATIONS IN JOINT SYSTEMS FOR WELDED TRACK

A separate standard for joint bars and fasteners to be applied between welded rail strands is being considered. There is some interest in the need for a higher strength system of bars and fasteners in welded rail than is necessary for jointed track. A study will be initiated to determine the extent to which joint bars and fasteners are being utilized in welded track and establish the need for a specification covering this type of system.

Report on Assignment 7

Metallurgical Effect of Rail Cropping Methods

S. H. Barlow *(chairman, subcommittee)*, R. M. Brown, J. T. Collinson, P. K. Cruckshank, A. R. DeRosa, C. E. R. Haight, V. E. Hall, W. S. Lovelace, A. B. Merritt, Jr., C. O. Penney, G. S. Triebel, E. H. Waring, C. E. Weller, D. J. White.

Subcommittee 7 submits as its final report a summary of the information developed under this assignment.

Methods used for cropping rail:

1. Circular steel blade, power saw.
2. Abrasive cutoff wheel (wet).
3. Abrasive cutoff wheel (dry).
4. Oxygen—gasoline torch (Petrogen).
5. Hack saw blade, power saw.
6. Oxyacetylene flame cutting torch.
7. Oxygen—propane flame cutting torch.

1. The AAR Research Center staff made a metallurgical investigation, reported in Bulletin 584, February 1964, pages 574–576, of cuts made on new 136-lb and secondhand 131-lb rail using a steel circular blade power saw.

It was noted that the heat generated in cutting caused the metal to flow out in rather extensive fins. The depth of the heat-affected zone varied from 0.043 to 0.020 inches and the BHN ranged from 603 to 614 compared to the regular rail metal range of 255 to 275. This indicates that the heat-affected zone consists of a martensitic structure which was confirmed by examining the specimen at 1000X magnification.

The heat-affected zone caused by this method is not as great as the zone caused by some of the earlier abrasive cutting methods and may not have any harmful effect even though the presence of martensitic structures is never desirable. It would seem that the martensitic metal could be easily transformed by heating the rail ends after cropping to a temperature between 800 to 1000 F, at which temperature the martensite transforms to a desirable grain structure.

2. The AAR Research Center staff investigated abrasive cutoff wheels (wet) (Bulletin 586, June–July 1964, pages 852–854) using a 26-inch abrasive cutting wheel at 1100 rpm. Cutting speed was regulated by the air-hydraulic feed of the wheel into the rail. After tests of cuts made in 11 seconds to 2 minutes, the cutting speed was adjusted to 40–45 seconds which provided a clean welding surface. At this cutting speed, 40 cuts were made which reduced the wheel diameter from 26 to 20 inches and ended its useful life.

The rail welding surface was free of any undesirable surface effects and was prepared by deburring only.

3. The AAR Research Center staff investigated dry abrasive cutoff wheels, reported by this committee in Bulletin 586, June–July 1964, pages 855–864. The rail cross sections used for this investigation were cropped in track by an Obear saw on the Union Pacific and it was found that martensitic structures existed to a depth of 0.046 to 0.086-inch in the web and on the edge of the base of rail.

Using this method only 9 to 14 cuts were obtained from a 26-inch wheel.

The presence of the martensitic structures in the thin sections of the rail at the end have not proven harmful, but they certainly are not desirable meatallurgically.

4. The AAR Research Center staff investigated the oxygen–gasoline (Petrogen) cutting torch (Bulletin 598, February 1966, pages 483–488) using three 5/8-inch rail slices cropped with this torch. After these three specimens were etched with a 3 percent nital solution, a thin layer of skin having an excess of cementite, the heat-affected area, the depth of hardness penetration and the base metal could be observed.

TABLE 1

DEPTH MEASUREMENTS OF THE VARIOUS LAYERS OBSERVED IN MICRO SPECIMENS TAKEN FROM RAIL SLICES CUT WITH AN OXYGEN-GASOLINE (PETROGEN) CUTTING TORCH

Sample	*Max. Depth of Thin Layer Having Excess Cementite (Inches)*	*Max. Depth of Heat Affected Area (Inches)*	*Max. Depth of Hardness Penetration (Inches)*
1H	.013	.125	.100
1B	.007	.344	.212
2H	.013	.173	.130
2B	.007	.252	.200
3H	.015	.212	.157
3B	.012	.500	.312

TABLE 2

HARDNESS SURVEY OF MICROSTRUCTURE TAKEN FROM RAIL SLICES CUT WITH AN OXYGEN–GASOLINE (PETROGEN) CUTTING TORCH (HARDNESS READING TAKEN WITH A TUKON HARDNESS TESTER AND CONVERTED TO B.H.N. READINGS)

Sample	*Thin Layer Having Excess Cementite*		*Hardened Area of Heat Affected Zone*		*Base Metal*	
	K.H.N.	*B.H.N.*	*K.H.N.*	*B.H.N.*	*K.H.N.*	*B.H.N.*
1H	395	365	347	318	290	265
1B	370	342	370	342	261	240
2H	409	377	365	337	322	294
2B	395	365	348	319	308	280
3H	394	356	514	463	267	246
3B	351	322	371	343	289	264

This method of cropping rail for oxyacetylene pressure butt welding is not recommended unless the cementite and heat-affected area are removed by other means.

Because of the large quantity of metal removed (flashed-out) during the electric-flash butt-welding process, cropping by an oxygen–gasoline torch may be acceptable, but if cementite becomes entrapped in the weld interface during the welding process, a weld failure may result.

No AAR Research Center investigations were made on the hack power saw, oxyacetylene flame cut or the oxygen–propane flame cut.

It is the opinion of your committee that this assignment has been completed for all practical purposes and it is recommended that this assignment be dropped.

Report on Assignment 9

Standardization of Rail Sections

E. H. Waring (*chairman, subcommittee*), S. H. Barlow, R. M. Brown, R. D. Claborn, M. W. Clark, C. E. R. Haight, V. E. Hall, W. F. Huffman, A. B. Merritt, Jr., B. F. Overbey, R. C. Postels, J. M. Rankin, I. A. Reiner.

During the past year Subcommittee 9 has secured from Canadian and United States rail mills a summary of the tonnage rolled and tonnage shipped in each rail section. A tabulation of that information is presented below.

It is noted that 981,565 tons or 79.82% of the total rail rolled in 1971 was in the sections to which it is recommended that purchases of new rail be limited, while 849,060 or 79.97% of the total rail shipped directly to North American member roads was in recommended sections.

This report is submitted as information.

Rail Rolled and Shipped by Weight and Sections
1971

		Rolled		*Shipped*	
Weight	*Section*	*Tons*	% *Total*	*Tons*	% *Total*
140*	AREA	70,087	5.70	64,573	6.08
136	NYC	2.036	0.17	1,548	0.15
136*	AREA	177,298	14.42	132,004	12.43
133	AREA	87,584	7.12	65,171	6.14
132*	AREA	337,703	27.46	305,540	28.78
131	AREA	1,495	0.12	1,103	0.10
130	AREA	566	0.05	539	0.05
130	REHF	1,215	0.10	1,017	0.10
122	CB	58,619	4.77	54,548	5.14
119*	AREA	143,223	11.65	121,904	11.48
115*	AREA	219,374	17.84	195,561	18.42
112	AREA	1,774	0.14	1,551	0.15
100	ARA–A	73,345	5.96	68,254	6.42
100*	AREA	13,372	1.09	11,969	1.13
100	ASCE	4,316	0.35	4,061	0.38
100	REHF	972	0.08	972	0.09
90	ARA–A	20,508	1.67	17,509	1.65
90	ASCE	479	0.04	456	0.04
85	ASCE	11,158	0.91	9,758	0.92
85	CPR	20	—	20	—
80	ASCE	4,507	0.36	3,719	0.35
Total		1,229,651	100.	1,061,777	100.

*Sections listed on page 4–M–2 of the AREA Manual as those to which it is recommended that purchases of new rail be limited.

Report of Committee 31—Continuous Welded Rail

B. J. Gordon, ***Chairman***

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R. E. Dove
R. H. Dunn
B. R. Forcier
R. E. Frame
L. D. Freeman
A. H. Calbraith
R. G. Garland
W. J. Gilbert
C. W. Grater
G. J. Harlock
J. W. Harper
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R. R. Hart
L. R. Henderson
R. S. Henry
J. T. Hiner
M. C. Holowaty
J. T. Hunter
R. A. Hunziger
T. B. Hutcheson
B. J. Johnson
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J. A. MacNab
G. H. Maxwell
C. E. McEntee
A. S. McRae
C. R. Merriman
M. Michaud
C. E. Morgan (E)
J. P. Morrissey
S. H. Poore (E)
B. R. Prusak
F. L. Rees
M. S. Reid
E. C. Rudolph
H. L. Rose
R. Rotter
C. N. Scott
T. C. Shedd
L. H. Shisler
C. R. Strutz
R. L. Teeter
R. L. Thornton
G. R. Thurston
R. H. Uhrich
H. J. Vale
C. W. Wagner
M. S. Wakely
E. H. Waring
C. E. Weller

Committee

(E) Member Emeritus.

Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Fabrication.

   No report.

2. Laying.

   Progress report, presented as information .... page 338

3. Fastenings.

   No report.

4. Maintenance.

   No report.

7. Field welding.

   No report.

8. CWR field handbook.

No report.

The Committee on Continuous Welded Rail,
B. J. Gordon, *Chairman.*

Report on Assignment 2

Laying

E. Eskengren *(chairman, subcommittee)*, R. M. Brown, M. E. Byrne, J. E. Campbell, R. E. Dove, B. J. Gordon, J. W. Harper, L. R. Henderson, B. J. Johnson, F. L. Rees, M. S. Wakely, E. H. Waring.

Your committee submits as information the following statistics showing the number of track miles of CWR laid, by years, since 1933.

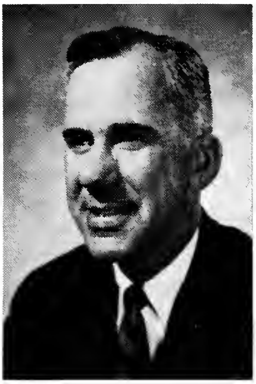
Track Miles of Continuous Welded Rail Laid by Years, 1933–1972

Year	Miles	Year	*Oxy-acetylene*	*Electric Flash*	*Total*
1933	0.16	1955	194.50	72	266.50
1934	0.95	1956	372.33	89.10	461.43
1935	4.06	1957	390.47	159.65	550.12
1936	1.52	1958	148.11	312.13	460.24
1937	31.23	1959	378.65	691.92	1070.57
1939	6.04	1960	299.42	961.20	1260.62
1942	5.48	1961	94.13	926.50	1020.63
1943	6.29	1962	310.59	1183.34	1493.93
1944	12.88	1963	497.52	1360.48	1858.00
1945	4.81	1964	586.76	1796.74	2383.50
1946	3.91	1965	700.59	1655.74	2356.33
1947	18.70	1966	746.61	1984.71	2731.32
1948	29.93	1967	784.28	1800.27	2584.55
1949	33.05	1968	643.10	2543.61	3186.71
1950	50.25	1969	674.35	2930.01	3604.36
1951	37.25	1970	800.30	5378.32	6178.62
1952	40.00	1971	504.28	3604.72	4109.00
1953	80.00	1972	422.91	4011.29	4434.20
1954	87.00				
					40464.14

Break-Down of Continuous Welded Rail Laid in 1972—Track Miles

	Oxyacetylene		*Electric Flash*		*Totals*
	New	*Second-Hand*	*New*	*Second-Hand*	
Main Track	198.32	194.60	2570.90	1289.75	4253.57
Sidings and Yard Tracks	0.16	29.83	32.10	118.54	180.63
	198.48	224.43	2603.00	1408.29	4434.20

Report of Committee 32—Systems Engineering



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B. W. H. Jaeger
R. H. Johnston
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A. W. Polich
B. H. Price, Jr.
F. G. Schurman
R. M. Soberman
J. J. Stark, Jr.
H. E. Storey
R. L. Sumner
T. W. Toal
E. N. Wilson
T. P. Woll

Committee

Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Define and illustrate systems engineering concepts, developing a manual of specifications for their application to railway engineering.

   Progress report, presented as information .... page 342

2. Document present computer assignments of all AREA Committees—indicating their relationships in overall systems—with identification of potential for expansion.

   No report.

3. Develop specifications for engineering administrative systems, such as PERT, CPM Time and Cost.

   No report.

4. Define and specify all elements in the engineer–computer interaction, promoting simplified and expeditious computer usage by the engineer in all his functions.

   No report.

5. Promote computer usage by railway engineers through demonstrations, seminars, and programs of instruction by leaders in the field.

   No report.

6. Formulate a railway engineering data base suitable for computer processing, collaborating as necessary or desirable with Committees 11, 16 and 22, the AAR Data Systems Division and the Cost Analysis Organization of the AAR Economics and Finance Department.

   (a) Specify the degree of detail for reporting maintenance of way and structures costs.

   (b) Identify all significant cost-associated physical factors, such as track and roadway construction and geometry, and structure design and construction, and specifying the necessary elements in their file assembly.

   (c) Assist in modeling, analysis and processing of available data.

   No report.

7. Design and develop in full scope a clearance system for both excess weight and dimensions of vehicles and loads.

   (a) Specifying all the system elements involved and their logical inter-relationships, and

   (b) Coordinating the interests and requirements of all involved AREA–AAR Engineering Division committees with those of AAR Mechanical and Operating–Transportation Divisions and the AAR Management Systems Department.

   No report.

COMMENT

The present assignments as listed above have been under discussion for some time, the general feeling being that they are far too broad and almost impossible to approach, particularly so as they encompass preparation of specifications, the design and development of an engineering system or the formulation of a data base. These are highly complex and sophisticated areas which would require a full-time effort by many highly competent people.

The present subcommittee chairmen have furnished their recommendations and together with several concerned members of the committee have redrafted the committee assignments as shown below. These revised assignments were presented to the Committee at its meeting in Atlanta in October 1972 and unanimously passed by the voting members present. They were approved by the Board of Direction at its meeting in November 1972.

You will note that the general assignments remain broad in scope and generally include most of the subject matter of the original. However, they have been broken down into manageable segments which reflect current interest and/or importance. Also, it should be noted that the thrust of the committee's effort has been shifted to that of documenting and reporting of engineering systems development within the railway industry rather than preparation of specifications and manuals. It is the opinion of the large majority of the committee that it can best function in this direction and that this is where its real value lies.

The sub-topics shown under Assignments 2, 3, 5 and 6 are those which appear to be receiving large attention at this time. It is intended that as these are fully investigated and reported that they will be replaced by other topics of interest. Also, additional topics may be added at any time as necessary or desirable. In this manner a large spectrum of engineering systems may be considered.

Committee 32 will consider these revised assignments effective following the Annual Convention in March 1973. In the meantime the committee will be restructured to fit its new direction.

THE COMMITTEE ON SYSTEMS ENGINEERING,
H. L. CHAMBERLAIN, *Chairman.*

REVISED ASSIGNMENTS FOR INVESTIGATION AND REPORT

A. Recommendations for further study and research.

B. Manual and revision of Manual.

1. Define systems engineering and illustrate systems concepts with applications to railroad engineering.

2. Administrative systems—Disseminate information pertinent to design and implementation, including specific applications or techniques within the scope of railroad engineering.
   (a) Clearances—excess weight and/or dimension.
   (b) Engineering applications of managerial accounting.
   (c) Roadway equipment systems.
   (d) Structures inventory systems.
   (e) Further subjects as assigned.

3. Technical applications—Disseminate information pertinent to the design and implementation of computer solutions to specific engineering design and analysis problems,
   (a) Yards and humps.
   (b) Use of engineering graphics.
   (c) Structures—design and analysis.
   (d) Further subjects as assigned.

4. Compile a digest of present railroad engineering systems applications, including all present systems-oriented applications of the assignments of other AREA committees.

5. Systems engineering education—Collect and disseminate information to the Association membership by means of special features, seminars, demonstrations and printed material.
   (a) Special presentations at Regional and Annual Meetings.
   (b) Glossary of terms.
   (c) Further subjects as assigned.

6. Provide interface for coordination of effort in railroad engineering systems.
   (a) Between railroads.
   (b) Between AREA and AAR Data Systems Division.
   (c) Between the Committees of AREA.
   (d) Between AREA and DOT (FRA).

Report on Assignment 1

Define and Illustrate Systems Engineering Concepts, Developing a Manual of Specifications for Their Application to Railway Engineering

W. E. Dowling *(chairman, subcommittee)*, R. J. Berti, W. R. Bjorklund, A. P. Campbell, Jr., A. V. Dasburg, L. P. Diamond, R. Dironvis, E. H. Fisher, A. J. Gellman, H. N. Laden, J. F. Lynch, Jr., G. F. McGlumphy, H. L. Murphy, A. W. Polich, B. H. Price, Jr., H. E. Storey, E. N. Wilson.

The following preliminary report, submitted under the auspices of Subcommittee 1, represents a compilation of several sources and is presented for the purpose of inviting commentary.

Introduction

This report is concerned with making generalizations regarding some of the basic concepts, objectives and resources of Systems engineering.

These concepts are corollaries, or are easily drawn consequences of a fundamental point of view in Systems engineering—that decisions in industry planning should not be arrived at by merely considering the separate areas of the problem but the behavior of all components must be carefully investigated together. Systems engineering provides a basis for the organized approach to decisions in complex railway transportation planning involving not only the technical and feasibility aspects of the problem but also can include the variable effects of economic, social, legal and all other applicable considerations. The interaction between the several parts or aspects of the project can be analyzed with considerable benefit, therefore the analysis of the project should be identified with and include the entire relationship between objectives, performance, costs, alternate solutions, etc.

The significance of Systems engineering is that it is an approach, or a technique, that will provide a scientific basis for management decisions. The Systems engineering approach will permit the development of urgently needed valid techniques that will adequately measure the complex elements of railroad transportation problems. It need not supplant traditional methods. It is intended to help management test whether they have set explicit goals and objectives, whether they have considered alternatives and organized their efforts toward desired goals and objectives.

Systems engineering is not a distinct or unique scientific method. So far as railroad transportation is concerned it is a mixture of engineering design, cost accounting, economic analysis and other intellectual endeavors. Systems engineering is an organized application of all combinations of the above-named disciplines with the objective of improving past analysis methods and developing solutions to problems. It encompasses a trend toward the development of mathematics as the common language to be used for Systems analysis, research and design. Thus is the Systems engineering technique made possible by the mathematical skills of the engineer.

The Systems Engineering Approach

A. Practices and Attitudes

The methods of Systems engineering includes a great deal of operations research technique which in turn is a derivative of the "scientific method" employed successfully by scientists for decades in explaining the physical world. The basic difference is that the scientist with his scientific method uses general knowledge applied to a specific inquiry to explain physical phenomena. The Systems engineer on the other hand works entirely at the level of specific problems. His challenge is that of finding a small number of changes that will have substantial effects on the major parts of the System. The Systems engineering approach is to seek the minimum effort that will bring about a transition to a more efficient operation. This approach aims at planning the arrangement of things and people which operate collectively as a system to yield significantly more desirable results than are produced at present.

Another consideration of Systems engineering is the use of systems analysis which is a methodology implying logical procedures which if correctly used will produce a predictable set of results. Systems analysis is in fact a discipline bringing together science and engineering technology to break down complex large-scale problems in an objective, logical and complete way so that we gain the necessary understanding and control to provide a scientific basis for management decisions.

Systems engineering also includes concepts of man interaction with mechanical–electrical communication systems which extend the limits of communication and control into apparently boundless areas combining man's technical skills with those things which mechanical–electrical machines can do best. The electronic computer is the chief component and has become the symbol of this development. The systems approach is based upon developing a complete profile of the project problem by defining the results desired, pinpointing the need for these results, establishing goals and objectives in terms of output or project effectiveness. The computer is relied on to assist in evaluating and relating facts and relationships. It aids in providing a total rather than a fragmentary look at the problem.

B. Effective Procedures

Successful application of the Systems engineering approach requires judgment as to effective procedures as well as technical and analytic skills. If we fail to make the appropriate evaluation of results or lose sight of the true long-range objectives, we may adversely influence the real world project. Therefore, the analysis must be identified with and include the complex relationships between objectives, performance, costs, alternate solutions, etc.

One of the problems facing railroad management today is the application of its information-processing capabilities to information and control needs. Successful systems demand continual and near instant communication of information. An information system must be created to deal with the complexity, interaction and continual change of objectives.

Systems engineering may be conveniently divided into four major and basic considerations: development of objectives and problem identification, the establishment of criteria, consideration of alternate solutions and performance review and evaluation.

1. Development of Objectives and Problem Identification:

The first and basic problem faced by a Systems engineering team is to define the problem that must be solved. The basic approach should be to consider the objectives rather than specific problem areas.

The most immediate and important task of Systems engineering analysis is to develop a definition of what is to be accomplished by the proposed system. Generally objectives are presented to the systems team in broad terms and must be converted into specifications which will permit the development of several approaches. An explicit formulation of the objectives of the analysis is necessary before the establishment of the more detailed system criteria. Problem identification is an especially important aspect of the planning process and a basic feature of effective procedure is to develop the set of objectives early in the analysis process. These objectives determine desired system performance characteristics and comparing them with actual performance is the first step in problem identification.

2. Establish Criteria:

The inclusion of a range of experts on a Systems engineering team permits decisions to be made with a comprehensive examination of the total environment. Of equal advantage is the ability of such a team to bring all relevant variables to bear on the solution. The relevant variables or approximate boundaries of the analysis is difficult to determine. Most difficulties encountered when systems analysis is attempted are the result of those things which were not considered—yet it is impossible to apply all influences to the analysis. Systems analysis boundaries have to be determined subjectively—by experience, judgment and argument.

3. Consideration of Alternate Solutions:

The evaluation of alternate solutions to a project problem in terms of the developed objective is often a difficult part of the analysis, yet all satisfactory Systems engineering procedures should develop alternate solutions. The prediction of the performance of proposed alternatives often requires additional skills to consider some of the more detailed aspects of the proposed alternative solutions.

4. Performance Review and Evaluation:

The most complex phase of the systems analysis in planning is the review and evaluation of performance in a simulated system. The performance of the system ideally should conform to the following requirements:

a) It should be objective oriented. It should come up with results in terms of objective achievements. Objective results measure the effectiveness of the system. b) Alternatives should be discernable. Results, effects, costs and options should be available for each major input. c) Major variable inputs should be evident so that management may concentrate on crucial variables. d) The effort should be related to environment but with potential projection into the future. Management makes decisions within real environment, not in the abstract, and should be able to identify future consequences of making current decisions. e) The System, if designed properly, will permit continual evaluation in order to minotor progress in achieving objectives.

The Resources of Systems Engineering

A. The Function of Various Theories

Many theories of analysis have a very important impact on the Systems engineering approach to complex problems. New statistical methods, advanced probalistic concepts, optimizing models, new mathematical technology to manipulate data and advanced computer science are but a few methods by which to deal with complexity and permit the Systems engineer to consider systems with much broader boundaries, more complex internal structure and to choose among many alternative analytic procedures.

With man's limited ability to cope with the complexity of the world, analysis theory has assumed the function of an analytical tool and permits breaking up reality into smaller, more meaningful segments.

Decision theory stresses the idea of the number of alternatives available to management, the criteria for decision making and the difference between criteria for an organization and criteria for an individual within an organization.

B. Organization

The diversity of project problems clearly requires that they be approached in an organized manner. It is usually necessary to organize teams to attack these problems. These teams not only include engineers but specialists from many fields. Developing a large area of ideas also serves to improve the ability of the engineers to communicate with other specialists. An extremely important element of team effort in systems analysis and design is that methods be available for effective exchange of information between the various disciplines and that all members of the team have the ability to communicate with each other. The team approach requires that individuals with a variety of skills work in a coordinated fashion to solve major problems and the complex nature of these problems requires that they be considered by a team in a unified effort.

C. Implementation

The electronic computer evolved concurrently with Systems engineering. The solution of all reasonable alternatives and the search for an optimum solution requires repeated calculations of such number that only an electronic computer can accomplish them in a reasonable time. A qualitative study of a complex system with hundreds of variables can only give limited information if not analyzed with an electronic computer. Any other approach is piecemeal and does not come up with the intricate behavior of the system. High-speed computers, data processing machines, communications equipment, calculators, copying machines and similar devices are the tools used for mathematical computation and data analysis in general. Their use is dictated by the requirements of the various techniques.

Techniques are methods used by the engineer to organize and analyze the data from a systems analysis and arrive at valid conclusions. Mathematics, while a technique in itself, is the backbone of most systems analysis methods. Analytical techniques, under various names and in various stages of development, contribute 1) to the basic theoretical aspects of the Systems engineering, 2) to developing the problem, 3) to constructing the mathematical model, 4) to testing the solution, 5) to setting controls over the solution and 6) to putting the results to work. That is to say—implementation.

The advantages from successful application of Systems engineering tools and techniques, the use of mathematical modelling, the necessary use of computers—in short the Systems engineering method—is one of the most hopeful approaches to rail transportation problems.

Cost Considerations

The cost and time to implement a project system can only be discussed in the most general terms, since requirements of one analysis can vary from those of another over an enormous range. In general, both the cost and the time to complete a project problem is dependent upon three principal variables: the size and complexity of the project, the team required, and the depth or extent of study required. The size and complexity can determine the study required. With regard to the team, the question is how many engineers, computer analysts and other skills are required. Depth of study implies not only work needed to develop the system's objectives and criteria but the time required to generate alternative schemes. The study should answer such questions as: does all the data need to be developed or is some of it currently available; and should a computer necessarily be required.

The cost of a system analysis of a unique problem can become exorbitant. However, development costs might be spread throughout a number of applications and it is usually desirable that an analysis system be common to other systems required by other applications.

Summary

Obviously the old practices and procedures developed for less sophisticated control do not always fit the new technologies. Industry has come to realize that transportation needs, control of pollution and most all urban problems are bound within dynamic operating systems requiring complete appraisal of economic, social and legal considerations. System engineers are mobilizing resources to help resolve these problems to which the professional skill of the railway engineer can indeed make substantial contributions.

Report of Committee 20—Contract Forms

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R. W. Humphreys, *Vice Chairman*

W. F. Burt, *Secretary*

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P. J. Freeman
E. E. Zacharias
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F. M. Jones
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D. F. Lyons
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C. G. Nelson
G. W. Patterson (E)
J. L. Perrier
C. W. Smith
W. R. Swatosh (E)
W. B. Tittsworth, Jr.
J. R. Vecchio
P. P. Wagner, Jr.
Committee

(E) Member Emeritus.

Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.
No report.

1. Form of agreement for trackage located in industrial parks.
No report.

2. Form of contract (short form) for miscellaneous work.
No report.

3. Form of agreement for filling, grading or disposing of waste materials on company property.
No report.

4. Form of agreement for emergency work.
No report.

5. Bibliography on subjects pertaining to contract forms.
No report.

The Committee on Contract Forms,
E. A. Graham, *Chairman*.

Report of Committee 27—Maintenance of Way Work Equipment

C. R. Turner, *Chairman*
F. H. Smith, *Vice Chairman*
C. H. Olds, *Secretary*
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L. J. Calloway
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J. O. Elliott
V. L. Emal
V. R. Erquiaga
E. H. Fisher
W. D. Gilbert
W. J. Gilbert
W. J. Gottsabend
N. W. Hutchison (E)
R. A. Hostetter
C. Q. Jeffords
R. M. Johnson
M. E. Kerns (E)
C. F. King
E. W. Knight
W. F. Kohl
W. E. Kropp (E)
H. F. Longhelt
G. J. Lyon
W. A. MacDonald
R. L. Matthews
A. E. Morriss, Jr.
C. A. Peebles
R. S. Radspinner
R. H. Richmond
T. R. Rigsby
J. W. Risk (E)
R. T. Ruckman
D. Schultz
J. T. Smith
R. A. Smith
M. M. Stansbury
E. A. Stewart
W. O. Tracy, Jr.
S. E. Tracy (E)
J. A. White, Jr.
N. White
J. W. Winger
G. L. Zipperian

Committee

(E) Member Emeritus.

Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.
No report.

1. Improvements to be made to existing work equipment.
No report.

2. Machine design.
No report.

3. Rail heaters and coolers for laying continuous welded rail, collaborating as necessary or desirable with Committee 31.
No report.

4. Actual cost to operate a piece of work equipment.
No report.

5. Propose minimum information about machines for manufacturers to give in advertising fliers and brochures sent to railroads.
   No report.

6. Study utilization of cars used by maintenance of way departments, such as ballast cars, equipment transport, tie cars, rail cars, etc.
   No report.

THE COMMITTEE ON MAINTENANCE OF WAY WORK EQUIPMENT,
C. R. TURNER, *Chairman.*

Report of Committee 3—Ties and Wood Preservation

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C. P. **Bird**,
Vice Chairman
R. G. Zietlow, *Secretary*

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D. E. Embling
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R. S. Henry
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L. W. Kistler (E)
M. A. Lane
W. G. Merritt
G. H. Nash
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T. H. Patrick
J. A. Peebles
R. B. Radkey
H. E. Richardson
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J. T. Skerczak
R. B. Smith
G. D. Summers
R. C. Weller
F. M. Whitmore
J. L. Williams
E. L. Woods
C. W. York
Committee

(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

B. Revision of Manual.

2. Cross and Switch Ties:
   (a) Keep up date specifications for cross and switch ties.
   (b) Extent of adherence to specifications for cross and switch ties as observed on field inspections, including:
      (1) Physical specifications.
      (2) Treatment specifications.
      (3) Plant and yard conditions.
   (c) Possible revision of cross tie design and/or spacing, collaborating as necessary or desirable with Committee 5.

   No report.

3. Wood Preservatives:
   (a) Keep up to date specifications for preservatives.
   (b) New preservatives.

   No report.

4. Preservative Treatment of Forest Products:
   (a) Keep up to date specifications for treatment.
   (b) Methods of conditioning prior to treatment.
   (c) Advisability of preparing specifications to cover care and handling of forest products before and after treatment.

   No report.

5. Service Records of Forest Products:
   - (a) Annual Tie renewal statistics as furnished by the Economics and Finance Department, AAR.
   - (b) Marine organisms.
   - (c) Service test records of forest products used in railroad construction and maintenance:
     - (1) Ties coated with products designed to extend service life.
     - (2) Termite control investigation.
     - (3) Compile record of various tie tests, past and present.

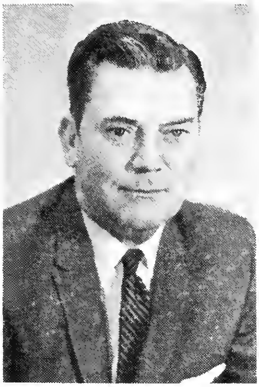
   No report.

6. Collaborate with AAR Research Department and Other Organizations in Research and Other Matters of Mutual Interest:
   - (a) Substitute for wood ties:
     - (1) Prestressed concrete ties:
   - (b) Splitting of ties and anti-splitting devices.
   - (c) Laminated ties.
   - (d) One-step seasoning and treating method developed by AAR–NLMA.
   - (e) Feasibility of using atomic energy to retard decay in forest products.
   - (f) Wood deterioration in the presence of metal.

   No report.

The Committee on Ties and Wood Preservation,
G. H. Way, *Chairman.*

Report of Committee 24—Engineering Education



H. M. Williamson, *Chairman*
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W. R. Catching
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H. E. Hurst
E. Q. Johnson
F. O. Johnson
A. V. Johnston
C. Johnston
T. D. Kern
C. E. Law
B. B. Lewis (E)
R. C. Michael
J. F. Pearce
L. P. Rossi
D. V. Sartore
P. S. Settle
R. M. Soberman
D. M. Tate
W. D. Taylor
D. L. Wilson
Committee

(E) Member Emeritus.
Those whose names are shown in boldface, in addition to the chairman, vice chairman, and secretary, are the subcommittee chairmen.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Recruiting.
Progress report, presented as information .... page 354

2. Summer Employment.
Progress report, presented as information .... page 358

3. Student Cooperative Programs.
Progress report, presented as information .... page 360

4. Student Affiliates.
No report.

5. Continuing Education.
No report.

6. Speakers.
No report.

7. Project Case Studies.
No report.

8. Exchange of Professional Staffs.
No report.

9. Research Resource Availability.
   No report.

THE COMMITTEE ON ENGINEERING EDUCATION,
H. M. WILLIAMSON, *Chairman.*

Report on Assignment 1

Recruiting

W. R. CATCHING *(chairman, subcommittee)*, W. S. AUTREY, J. B. CLARK, J. T. EVANS, E. T. FRANZEN, H. E. HURST, H. W. WILLIAMSON.

During the current year, your committee conducted its second annual survey of college graduates employed within the railroad industry during the 12 month period August 1971 to July 1972.

This year's survey again had the support of a considerable segment of the industry. Completed questionnaires were received covering 41 Class I line-haul railroads including all of the major companies, one Class II railroad and 10 switching and terminal companies.

Although 27 of the smaller Class I railroads did not reply, it is probable that very few college graduates were employed by these companies.

Briefly, the survey reports covering 52 companies indicate a high of 134 graduates employed by one major system, 29 other railroads employing one or more graduates and no graduates hired in the period by the remaining 22 roads. Table 1 provides a detailed summary of the academic degree, course of study and monthly beginning salaries of 464 graduates employed by 30 railroads during the 12 month period August 1971 to July 1972.

The average beginning salaries reported in this table reinforces the findings in our initial survey last year that railroad entering salaries for college graduates are fully competitive with similar national averages compiled and published by a large organization of college placement officers.

Table 2 presents information from the survey questionnaires in two areas that have been of particular interest to this committee:

1. Promotion of undergraduate employment during summer vacations and through cooperative education programs as a means of attracting college students to permanent railroad careers upon graduation, and
2. The use of formal training programs to indoctrinate and prepare new college graduates for future supervisory and managerial positions.

From Table 2 it can be noted that 67 college graduates had prior railroad experience, or nearly 15% of the 464 graduates employed. Also 170 graduates (about 37%) were initially assigned to training programs that averaged 10.4 months in duration.

The final section of the survey questionnaire requested information from each railroad on its plans for hiring college graduates in the 1972–1973 recruiting year. As the survey was conducted in September, a number of companies replied that their requirements for the coming year had not been determined. However, 24 railroads did respond with preliminary estimates, and Table 3 provides a detailed

TABLE 1. DEGREE, COURSE OF STUDY AND MONTHLY BEGINNING SALARIES OF COLLEGE GRADUATES EMPLOYED BY 30 RAILROADS IN THE 12 MONTHS AUGUST 1971 TO JULY 1972

Degree and Course of Study	Number of Employing Railroads	Number of Graduates Employed	Monthly Beginning Salaries Lowest	Highest	Average
ASSOCIATE DEGREE (Two years of study)					
Non-Technical Curriculum	1	5	$600	$ 715	$ 558
Technical Curriculum	8	49	710	980	780
Sub-Total	8*	54	$600	$ 980	$ 769
BACHELOR DEGREE (Business & Sciences)					
Accounting	7	18	$692	$ 900	$ 768
Business-General	14	94	550	1,175	812
Humanities & Social Sciences	8	50	640	1,200	798
Marketing & Distribution	8	10	750	900	799
Sciences (Chem., Math., Physics)	10	67	715	1,125	811
Sub-Total	22*	239	$550	$1,200	$ 805
BACHELOR DEGREE (Engineering)					
Civil Engineering	18	57	$800	$1,000	$ 883
Electrical Engineering	10	16	775	1,050	878
Industrial Engineering	7	13	800	1,060	879
Mechanical Engineering	11	22	800	1,085	906
Other Engineering	7	8	750	875	842
Sub-Total	21*	116	$750	$1,085	$ 883
GRADUATE DEGREE					
MS-Engineering or Sciences	5	6	$850	$1,000	$ 942
MBA-After Non-Technical Degree	8	37	750	1,250	938
MBA-After Technical Degree	4	6	800	1,150	929
JD, LLB or LLD - Law	2	6	975	1,188	1,028
Sub-Total	12*	55	$750	$1,250	$ 947
GRAND TOTAL	30*	464	$550	$1,250	$ 837

*Count of employing railroads by degree categories will not add to totals.

comparison of their 1972–1973 forecast with graduates employed in the previous two years.

Several changes in recruiting emphasis can be noted from this table.

During 1971–1972, there was a substantial increase in the employment of Associate Degree graduates with technical course of study and a similar increase in Bachelor Degree graduates majoring in business and sciences over those employed in 1970–1971. A primary reason for the increase in Associates and science majors can be related to expanded computer applications in revenue billing, car location and utilization, operating performance reports, etc., on most of the major railroads. Also, it is believed that candidates with the required skills apparently were generally more available in the past year to fill positions involved with data input, monitoring, quality control and related assignments. The demand for Associate Degree graduates is expected to continue in 1972–1973.

Although estimated 1972–1973 requirements for business and science majors and for graduate degree candidates are down from the 1971–1972 peak, the 24 railroads indicate a continuing need for more engineers. It can be noted from the table that the number of engineering graduates employed in 1971–1972 declined somewhat in contrast to sharp increases in other degree categories. Despite the availability of graduates with other degrees, it appears that competition for graduate engineers remains at a high level throughout industry generally.

TABLE 2. PRIOR RAILROAD EXPERIENCE AND INITIAL ASSIGNMENT OF COLLEGE GRADUATES EMPLOYED BY 30 RAILROADS IN THE 12 MONTHS AUGUST 1971 TO JULY 1972

Degree and Course of Study	Number of Graduates Employed: With Prior RR Experience: From Co-Op Programs	With Prior RR Experience: Summer Vacation	Without Railroad Experience	Total Graduates Employed	First Assignment: To Regular Position	To Formal Training Program	Training Period (Months)
ASSOCIATE DEGREE (Two years of study)							
Non-Technical Curriculum	-	-	5	5	5	-	(-)
Technical Curriculum	4	8	37	49	49	-	(-)
Sub-Total	4	8	42	54	54	-	(-)
BACHELOR DEGREE (Business & Sciences)							
Accounting	-	-	18	18	14	4	(11.6)
Business-General	1	15	78	94	35	59	(9.3)
Humanities & Social Sciences	-	5	45	50	26	24	(12.0)
Marketing & Distribution	-	1	9	10	2	8	(11.3)
Sciences (Chem., Math., Physics)	-	2	65	67	63	4	(5.3)
Sub-Total	1	23	215	239	140	99	(10.0)
BACHELOR DEGREE (Engineering)							
Civil Engineering	2	11	44	57	33	24	(10.6)
Electrical Engineering	1	-	15	16	10	6	(14.0)
Industrial Engineering	1	3	9	13	4	9	(10.2)
Mechanical Engineering	-	6	16	22	15	7	(11.1)
Other Engineering	-	1	7	8	3	5	(9.4)
Sub-Total	4	21	91	116	65	51	(10.9)
GRADUATE DEGREE							
MS-Engineering or Science	-	3	3	6	3	3	(12.0)
MBA-After Non-Technical Degree	-	2	35	37	23	14	(11.1)
MBA-After Technical Degree	-	1	5	6	3	3	(10.3)
JD, LLB or LLD - Law	-	-	6	6	6	-	(-)
Sub-Total	-	6	49	55	35	20	(11.1)
GRAND TOTAL	9	58	397	464	294	170	(10.4)

TABLE 3. COMPARISON OF COLLEGE GRADUATE RECRUITING PLANNED FOR 1972-1973 BY 24 RAILROADS VS GRADUATES EMPLOYED IN PREVIOUS YEARS

Degree and Course of Study	Railroads With Plans For 1972-1973	Graduates Employed 1970-1971	Graduates Employed 1971-1972	Graduates Needed 1972-1973	Increase or (Decrease) 1972-1973 vs 1970-1971	Increase or (Decrease) 1972-1973 vs 1971-1972
ASSOCIATE DEGREE (Two years of study)						
Non-Technical Curriculum	3	5	5	-	D (5)	D (5)
Technical Curriculum	12	11	39	42	I 31	I 3
Sub-Total	12*	16	44	42	I 26	D (2)
BACHELOR DEGREE (Business & Sciences)						
Accounting	10	8	14	16	I 8	I 2
Business-General	18	35	89	61	I 26	D (28)
Humanities & Social Sciences	13	30	40	9	D (21)	D (31)
Marketing & Distribution	15	33	10	24	D (9)	I 14
Sciences (Chem., Math., Physics)	11	25	67	29	I 4	D (38)
Sub-Total	21*	131	220	139	I 8	D (81)
BACHELOR DEGREE (Engineering)						
Civil Engineering	23	59	53	90	I 31	I 37
Electrical Engineering	14	16	16	20	I 4	I 4
Industrial Engineering	15	16	13	21	I 5	I 8
Mechanical Engineering	17	21	21	17	D (4)	D (4)
Other Engineering	13	11	7	8	D (3)	I 1
Sub-Total	24*	123	110	156	I 33	I 46
GRADUATE DEGREE						
MS-Engineering or Science	8	9	5	3	D (6)	D (2)
MBA-After Non-Technical Degree	11	28	36	16	D (12)	D (20)
MBA-After Technical Degree	10	12	6	7	D (5)	I 1
JD, LLB or LLD - Law	2	1	1	-	D (1)	D (1)
Sub-Total	15*	50	48	26	D (24)	D (22)
GRAND TOTAL	24*	320	422	363	I 43	D (59)

*Count of railroads with 1972-1973 plans by degree categories will not add to totals.

Report on Assignment 2

Summer Employment

W. A. Oliver *(chairman, subcommittee)*, T. M. Adams, W. S. Autrey, J. B. Babcock, R. H. Beeder, T. P. Cunningham, L. C. Gilbert, Claude Johnston, T. D. Kern, B. B. Lewis, V. J. Roggeveen.

In accordance with its practice, established in 1959, Committee 24 canvassed the railroads during December 1971 concerning their 1972 summer employment needs for engineering students. A brief but formal questionnaire was sent to the chief engineering and maintenance officers and chief personnel officers of the railroads of the United States and Canada requesting information about their requirements for the summer of 1972, as well as information about their program of the preceding one.

The following tabulation presents the results obtained from the questionnaire. For comparative purposes, the 1971 figures are also given. It should be noted that the total return of the questionnaire numbered 68 in 1972 as compared to a total of 40 in 1971. The total return is significant, particularly an increase, since it indicates a continuing interest in the program on the part of the railroads. Furthermore (28 + 9) = 37 railroads stated that they planned to employ students in the summer of 1972 as compared to (11 + 18) = 29 in 1971. These figures are encouraging. They could mean improved business conditions. The tabulation follows.

1972 Summer Employment

	Number of Railroads
Offering employment through Committee 24	9
Offering employment but *not* through Committee 24	28 (37)
No employment in 1972	31
Total return of questionnaire	68

1971 Summer Employment

	Number of Railroads
Offering employment through Committee 24	11
Offering employment but *not* through Committee 24	18 (29)
No employment in 1971	11
Total return of questionnaire	40

The returns obtained from those railroads offering summer employment through Committee 24 were tabulated, reproduced and submitted to some 125 engineering colleges throughout the United States and Canada where they were brought to the attention of students by posting on employment bulletin boards and through other means.

Information concerning summer employment by the railroads in 1971 was also requested in the questionnaire. It is a well known fact that the railroads have for many years been employing hundreds of college students during the summer vacation months. The following figures are only a partial indication of the total numbers employed that could have been reported by the railroads, not only *by* those answering the questionnaire but also by those not returning it. Consequently, while the figures are interesting, they should be noted with the understanding that they are far less than the probable totals obtaining in the entire railroad industry.

RESULTS OBTAINED FROM THE QUESTIONNAIRE CONCERNING
1971 SUMMER EMPLOYMENT

Engineering and other college students employed during the summer of 1971	1633
Number of repeats from the summer of 1970	848
Number of those employed during summer months who have become permanent employees	124

Committee 24 takes this opportunity to thank the railroads for the support they have given this project and requests their continuing cooperation.

Report on Assignment 3

Student Cooperative Programs

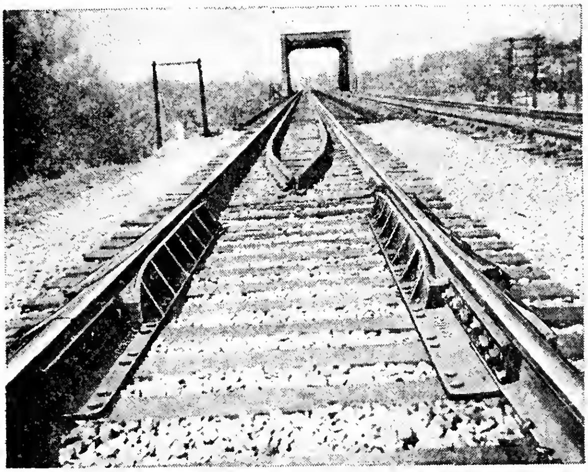
C. T. Yarbrough (*chairman, subcommittee*), R. M. Brown, A. W. Cooper, W. T. Hammond, W. H. Huffman, T. D. Kern, A. L. Sams.

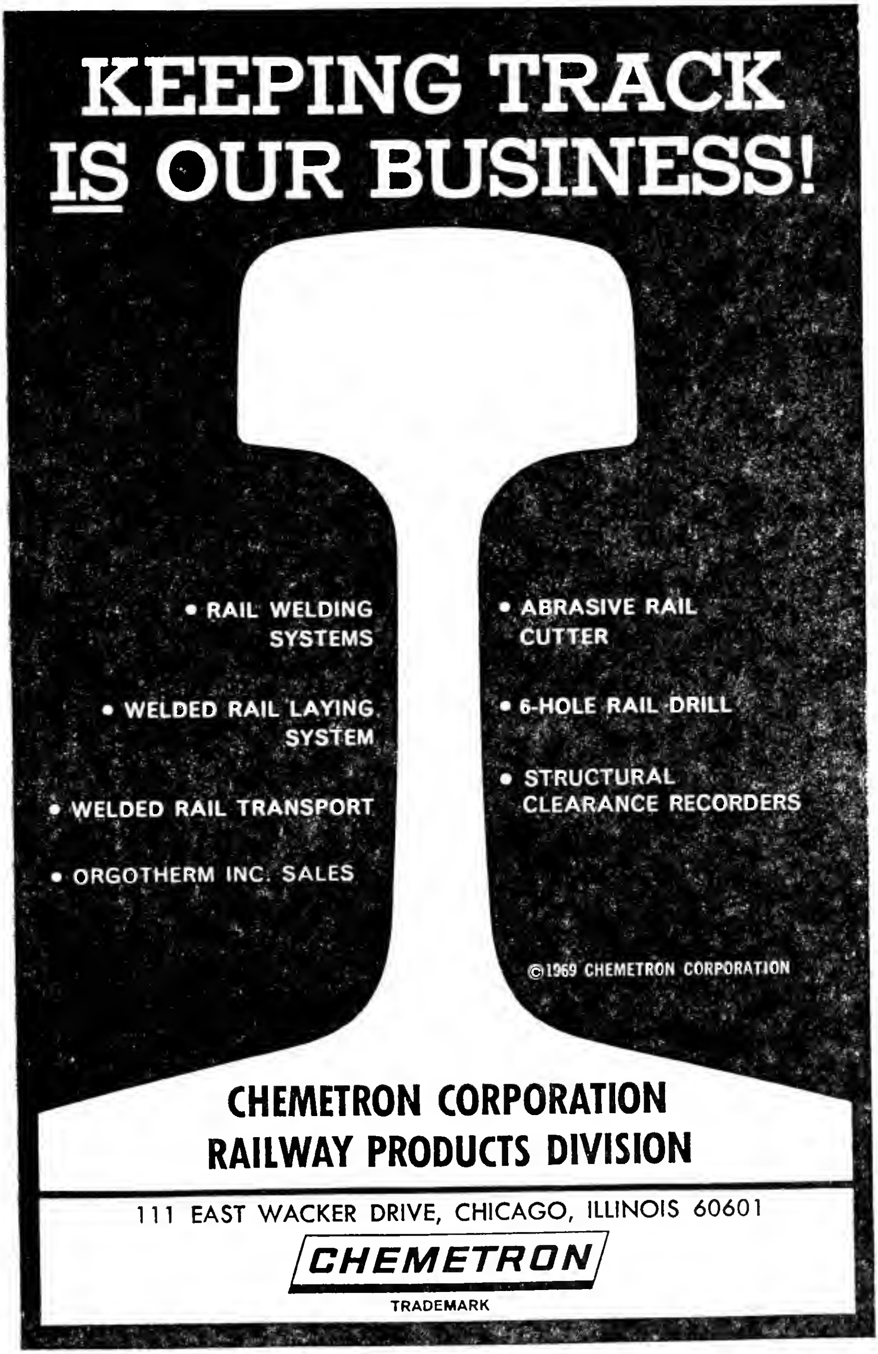
The subcommittee has identified the following universities as having cooperative programs in the engineering disciplines indicated:

Schools with Engineering Co-op Programs

School	*Civil Engr.*	*Elec. Engr.*	*Mech. Engr.*	*Indus. Engr.*	*Chem. Engr.*
Akron, Univ. of	x	x	x		x
Alabama, Univ. of, University, Ala.	x	x	x	x	x
Arizona, Univ. of, Tucson, Ariz.	x	x	x	x	x
Arkansas, Univ. of, Fayetteville, Ark.	x	x	x	x	x
Auburn University, Auburn, Ala.	x	x	x	x	x
Bradley Univ., Peoria, Ill.	x	x	x	x	
Bridgeport, Univ. of, Bridgeport, Conn.		x	x		
Calif. at Berkeley, Univ. of	x	x	x	x	x
Cincinnati, Univ. of	x	x	x		x
Cleveland State Univ., Cleveland, Ohio	x	x	x		x
Cornell University, Ithaca, N.Y.		x	x	x	
Detroit, Univ. of	x	x	x		x
Drexel Univ., Philadelphia, Pa.	x	x	x		x
Evansville, Univ. of		x	x	x	
Florida, Univ. of, Gainesville, Fla.	x	x	x	x	x
Florida Atlantic University, Boca Raton, Fla.			x		
Florida Inst. of Tech, Melbourne, Fla.		x			
General Motors Inst., Flint, Mich.		x	x	x	
George Washington Univ., Washington, D.C.	x	x	x		
Georgia Inst. of Tech., Atlanta, Ga.	x	x	x	x	x
Hampton Inst., Hampton, Va.	x	x		x	
Houston, Univ. of	x	x	x	x	x
Howard University, Washington, D.C.	x	x	x		x
Illinois, Univ. of, at Chicago Circle, Chicago, Ill.					x
Illinois, Univ. of Urbana, Ill.	x	x	x	x	x
Illinois Inst. of Tech., Chicago, Ill.	x	x	x	x	x
Indiana Inst. of Tech., Fort Wayne, Ind.	x	x	x		x
Iowa State Univ., Ames, Iowa	x	x	x	x	x
Kansas State Univ., Manhattan, Kansas	x	x	x	x	x
Lamar State College of Tech., Beaumont, Texas	x	x	x	x	x
Lehigh Univ., Bethlehem, Pa.		x			
Louisiana Tech University, Ruston, La.	x	x	x	x	x
Louisville, Univ. of	x	x	x		x
Maine, Univ. of, Orono, Maine					x
Marquette Univ., Milwaukee, Wisc.	x	x	x		
Maryland, Univ. of, College Park, Md.	x	x	x		x
Massachusetts Inst. of Tech., Cambridge, Mass.		x	x		

School	*Civil Engr.*	*Elec. Engr.*	*Mech. Engr.*	*Indus. Engr.*	*Chem. Engr.*
Michigan Tech Univ., Houghton, Mich.	x	x	x		
Michigan, Univ. of, Dearborn, Mich.		x	x	x	
Milwaukee School of Engineering		x	x		
Minnesota, Univ. of, Minneapolis, Minn.	x		x		
Mississippi State Univ., State College, Miss.	x	x	x	x	x
Missouri at Columbia, Univ. of	x	x	x	x	x
Missouri at Rolla, Univ. of	x	x	x		x
Nebraska, Univ. of, Lincoln, Nebr.	x	x	x	x	x
Nebraska, Univ. of, Omaha, Nebr.	x				
North Carolina Agric. & Tech. State Univ., Greensboro, N.C.		x	x		
North Carolina State Univ., Raleigh, N.C.	x	x	x	x	x
Northeastern Univ., Boston, Mass.	x	x	x	x	x
Northern Arizona Univ., Flagstaff, Ariz.	x	x	x		
Northwestern Univ., Evanston, Ill.	x	x	x	x	x
Oklahoma, Univ. of, Norman, Okla.	x	x	x	x	x
Pacific, University of the, Stockton, Calif.	x	x			
Pennsylvania State Univ., University Park, Pa.			x		
Pratt Inst., Brooklyn, N.Y.		x	x	x	x
Purdue Univ. at Lafayette	x	x	x	x	x
Rensselaer Poly. Inst., Troy, N.Y.	x	x	x		x
Rochester Inst. of Tech.		x	x	x	
Saint Mary's University, San Antonio, Texas				x	
South Alabama, Univ. of, Mobile, Ala.	x	x	x		x
South Florida, Univ. of Tampa, Fla.	x	x	x	x	x
Southern University A & M College, Baton Rouge, La.	x	x	x		
Southern Methodist Univ., Dallas, Tex.	x	x	x	x	
Southern Technical Inst., Marietta, Ga.		x	x	x	
Temple University, Philadelphia, Pa.		x	x		
Tennessee at Chatanooga, Univ. of		x	x	x	x
Tennessee at Knoxville, Univ. of	x	x	x	x	x
Tennessee at Martin, Univ. of	x	x	x	x	x
Tennessee State Univ., Nashville, Tenn.	x	x	x		
Tennessee Tech. Univ., Cookeville, Tenn.	x	x	x	x	x
Texas at Austin, Univ. of	x	x	x		x
Tri-State College, Angola, Ind.	x	x	x		x
Virginia Poly. Inst., Blacksburg, Va.	x	x	x	x	x
Washington Univ., St. Louis, Mo.	x	x	x		x
Washington, Univ. of, Seattle, Wash.	x	x	x		
Wayne State Univ., Detroit, Mich.	x	x	x	x	x
West Virginia Inst. of Tech., Montgomery, W. Va.	x	x	x		x
Western Michigan Univ., Kalamazoo, Mich.				x	

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• WELDED RAIL TRANSPORT
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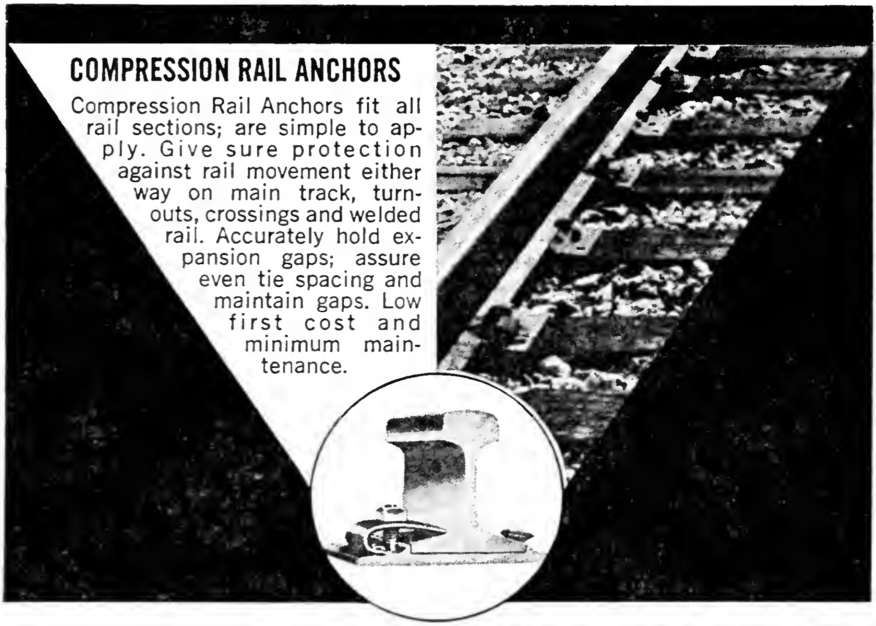
Patent Numbers: 3,102,690;
3,118,327;
3,159,198.



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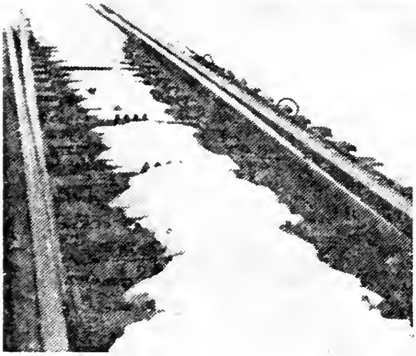

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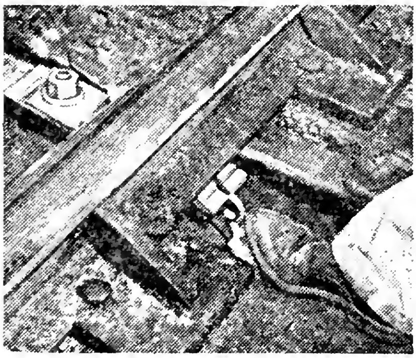

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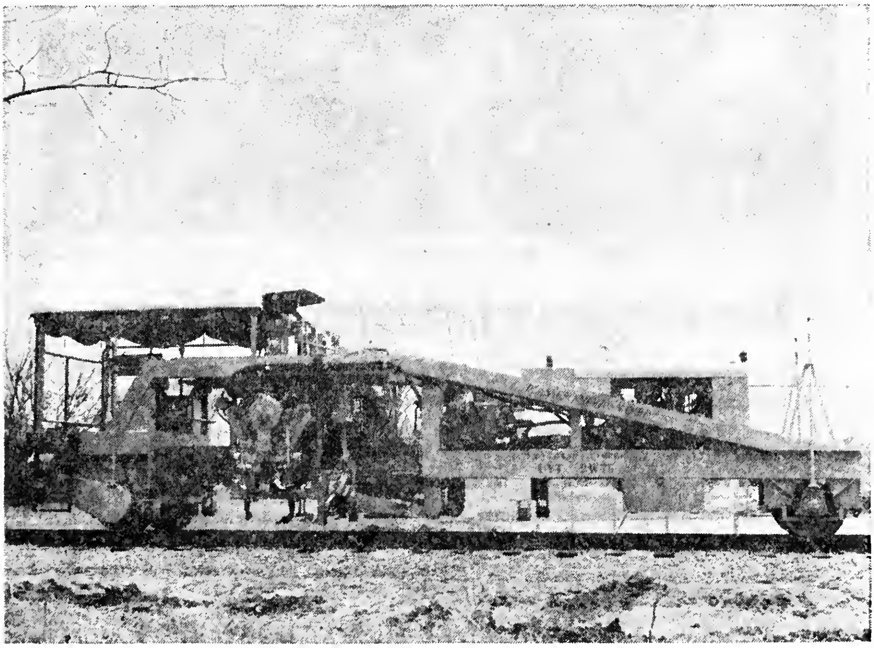

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REGIONAL MEETING

October 26, 1972

Regency Hyatt House, Atlanta, Ga.

Luncheon Address—
A Firm Base for Tomorrow's Progress

By L. STANLEY CRANE
Executive Vice President—Operations
Southern Railway System

Getting together with people from AREA is always like "old home week" for me. I have been a member of this fine organization for longer than I usually care to admit. But since I'm among friends, the year was 1946—and you can do the subtraction for yourselves.

It would not be an exaggeration to say that my associations with you have had an important part in making these very rewarding years for me.

I welcome the chance to talk with you today—it is always a pleasure to be among friends of long standing. I consider your role in the railroad business to be one of the most important factors in the success of our individual companies and of the railroad industry as a whole.

Quite literally, yours is *the basic part* of a basic transportation industry.

The track and roadway that you do so much to maintain, strengthen and improve is the basis for our entire railroad operation just as surely as railroads are the basis of America's total transportation system.

And I am glad to say that we are doing a great deal to strengthen both of these for today's traffic and tomorrow's growing transportation demands, and these growing transportation demands will be susbtantial. As Ben Biaganni told you in his keynote address before the Roadmaster's and B&B Association in Chicago last month—our marketing specialists predict that in the decade of 1970 to 1980 our economy will double its demand for transportation services. We believe that the railroads will maintain at least their present share of this market.

Think of what this means to you as related to track maintenance—doubling or in some cases tripling the tonnage transported over various line segments of our railroad.

Much of what I say will be familiar to you, and I make no apology for that. I'm not superman—and that's just about who it would take to tell this crowd of track specialists something about your jobs that was really new to you.

However, I do think that there is real value in pausing from time to time to take stock of where we are and where we are going. This is what I would like for us to do now.

What are we doing to strengthen our track structure—to make sure that it provides a strong base for tomorrow's progress?

For one thing, we are putting more money into the upgrading of our track and right-of-way than I can ever recall our doing in the past.

On Southern, for example, our maintenance of way ratio has steadily increased over the past few years. This means that in a time of growing revenues we are spending a greater portion of those revenues on the basic track structure.

Keeping our maintenance ratio high is a matter of deliberate decision. We regard this kind of spending as a very desirable way of building strength into our property to add to the efficiency and safety of rail operations, both now and in the future. It is really an investment in our future.

There is no question in my mind that other railroads look at this in much the same light and are themselves spending just as much on their track as earnings and prudent financial management will allow. You know as well as I do that we have to spend money on our track structure when earnings are reasonably good. Any belt-tightening that has to be done when earnings start to slack off usually hits the maintenance of way department first.

In good times or lean times, however, we have a clear obligation to use money and manpower judiciously to get the most good out of every dollar we plow back into our fixed plant. And here we have a number of factors working to our advantage. Among these is the use of more advanced track maintenance methodology to guide us in concentrating our efforts where they will produce the greatest benefit.

One example that comes readily to mind for me is the Research Car we put to work on Southern several years ago.

This is a thoroughly-instrumented rolling laboratory with an on-board computer. It helps us test and evaluate a number of track conditions while this car is moving in a train at freight train speeds. It provides an evaluation of the track under dynamic conditions.

Information developed by the Research Car has proved valuable to us in many ways. Not the least of these is the insight it helps give us into which track locations most need the attention of our timbering and surfacing crews or our rail-laying forces.

Of course, more factors than one affect our decisions on the priorities for track maintenance, just as they do yours. We know when each section of track was last surfaced, what the traffic density is at that location and what difficulties we may have had with the track there in the immediate past. But the Research Car gives us a pragmatic test of what the track condition is at a particular moment—whatever the time interval or our past experience indicates that it *should* be.

Before I get away from the Research Car, there is one point that I would like to make. In order to get the precisely instrumented equipment we needed to make this car work, we had to go to Switzerland. And the recent technical publications from Europe that I have seen give me the idea that suppliers in Europe may be well ahead of our own supply industry in developing new and more sophisticated track maintenance machinery.

So I would like to pose a friendly challenge to our suppliers of maintenance machinery. Here is a way that you can help us lay down a firm base for tomorrow's progress.

Don't just go on selling us last year's *good* track maintenance machine. Get out there and design next year's better one. Railroads need rugged track machines, geared for high production. Machines that are easy to operate and simple to maintain. We are counting on your research and your expertise to help develop them.

The importance of this cannot be overstated. Railroads have to concentrate on modern techniques of track laying and track maintenance. This is especially true of the use of tie replacement and ballast tamping machinery that gets our job done better at less total cost. This is not a new requirement, it is an effort of long standing and one that I am convinced has been the principal factor in keeping track maintenance costs from eating us all alive over the past dozen years or so. Costs are still rising and there is no reason to expect any change in this general trend.

Careful planning and scheduling of our maintenance work to make the most of the people and dollars we have available is another promising area of present study and future benefit. Our computers are giving us valuable help in this regard. And we have really only scratched the surface of what data processing and computer memory banks can do for us.

I don't know how many of you had the opportunity to sit in on the presentation made in Atlanta this week by Bob Tuve, our manager of quality control engineering. But those who did heard some interesting highlights of what Southern's computer is doing now and what we expect it to do in the future to help make our track maintenance more cost effective.

We have accumulated in the computer memory a master file of track characteristics throughout our railway system. It includes such information as the date when each section of track was laid, the weight of the rail, the traffic density on that part of the railroad, the most recent time the track was timbered and surfaced, and the latest data about that track developed by our Research Car. We have recently developed a tape-to-tape conversion to put Research Car data into this master file automatically.

What this does, in essence, is to create in the computer an ever-changing picture of track conditions throughout the railway. The next step is to define, in computer language, the critical factors that determine the relative need for track maintenance. Then we can program our computers to crank out track maintenance priorities as they now provide us with car and locomotive maintenance schedules.

We are all concerned, I know, with the new Department of Transportation standards for track maintenance. Some have already been established, others will be taking effect later.

All of these standards have the avowed purpose of increasing railroad safety—and with that *purpose* we can have no quarrel. Our problems are practical and economic. Will these standards work and can we afford them?

Much of what DOT wants us to do with regard to high-speed, heavy traffic lines we are either already doing—and in some cases doing more than they ask—or would be eager to do if we saw where the money was coming from.

What bothers me are the standards for lightly-used and low-speed lines—the branch lines, yard tracks and sidings. Not only are these more restrictive than I think really necessary, but in some cases they may not be possible to justify on any economic basis.

Each section of our railroad brings in a certain amount of revenue. The sophistication of our present cost studies is such that we know pretty well how much that is. If the DOT standards must be met at a cost that exceeds the revenue the line produces, you are really between a rock and a hard place. You will have to take a hard look at the operation of that line to see whether you can afford it or will have to seek permission to abandon it. To me, that seems a high price to pay for an unrealistic rule.

Even if we agreed—chapter and verse—with everything that DOT wanted us to do in the way of increased track maintenance, we would still be faced with the economic realities of the railroad's financial position.

The ability to make the improvements we *know* ought to be made—in track or rolling stock or anything else—depends to a large degree on the financial health of our railroad companies.

This was the underlying urgency behind our efforts in behalf of the ASTRO program and our support of the proposed Surface Transportation Act that grew out of this study. I know that you were as disappointed as I was that Congress left this important business unfinished in the rush to adjournment last week.

We are vitally interested in this legislative approach to the strengthening of our whole surface transportation system. And, fortunately, we have a lot of company. But right now we are in the same position as a number of football fans around the country. We will just have to "wait until next year."

But the fact that Congress took no substantive action this year on the transportation legislation we consider to be so important does not mean that no progress has been made.

Our national legislators have been devoting more concentrated attention to the problems of transportation than we have seen in years. And they were beginning to produce results.

The House of Representatives had hammered out a version of the Surface Transportation Act that showed real promise. It would have made five billion dollars in federally-guaranteed loans available to carriers to upgrade their equipment and services. It would also have provided a realistic program for the abandonment of little-used transportation facilities.

Representatives of water carriers, motor carriers and railroads showed unprecedented unity in support of this proposed legislation. Not long ago, we welcomed railroad labor organizations to the ranks of those lending active encouragement to the effort to make productive changes in transportation law. The Nixon administration also lent its support.

The less said about the Senate version of the bill the better. It would have made three billion dollars in guaranteed loans available—but it would also have placed very restrictive limitations on how the loans could be used. And it would have set a 28-month moratorium on rail abandonments. In short, the bill left a great deal to be desired as an attempt to achieve what transportation really needs.

Transportation will be high on the list of priorities for the new Congress that convenes in January. The House version of the Surface Transportation Act seems to offer by far the best framework for a new bill next year. But it isn't going to happen without hard work on our part.

To borrow a phrase from the coach of my hometown Washington Redskins "The future is now." It is up to us to help keep alive the momentum that has developed this year toward a legislative approach to deal effectively with some long-standing problems in transportation. We need very much the same kind of unity and involvement we have seen in the immediate past.

I urge you to give this legislation your active support again for the year ahead. This is an election year; let your elected representatives know how important you believe this legislation to be, for transportation and for our economy as a whole. Talk with your friends and associates. Do your part to help continue the groundswell of support for this legislation, because our experience this year makes it plain that we will surely need it.

In the areas of your special competence and particular responsibility, the last thing you need is a pep talk from me. You have long ago come to terms with the reality that our earliest railroad builders discovered and every track maintainer since has reaffirmed.

A railroad is never finished. No railroad is ever as good as it can be. It has to be rebuilt day by day and year by year as long as trains move over it. Our challenge is to make it better every time—and as you meet that challenge you have my sympathy, my admiration and my absolute confidence.

Thank you for letting me be with you.

Track Inspection

By THOMAS B. HUTCHESON
Assistant Vice President
Engineering & Maintenance of Way
Seaboard Coast Line Railroad

Until October 16, 1972, track inspections, their frequency, the details in which inspections are required, the standards against which they are to be made, and the records to be kept following inspection were prescribed by the rules and regulations of the several railroads.

On that date these matters became prescribed by rules issued by the Federal Railroad Administration as a requirement of the Federal Railway Safety Act of 1970. The act, for the first time, subjected the work of track maintenance officers to federally imposed rules and regulations, marking the beginning of a new era in track inspection and maintenance.

A time of change, Mr. Chairman, is proper time to look both to the past and to the future. I shall, therefore, discuss the central place which track inspection has always had in engineering and maintenance work throughout the years; some developments in the present day state of the art and, indeed, the science of track inspection; and speak briefly on the ultimate purposes of any track inspection.

This is particularly desirable on an occasion when so many of the younger members of the profession are present.

Track inspection has always been the first and most important task of a railway maintenance officer. It is the essential base from which all of his decisions evolve to develop a systematic program for the safe and economical operation of the track.

Let us look at some of the early beginnings of track inspection. Here is a track inspector (Fig. 1). You will note that the track which he is inspecting is not yet complete. He apparently is concerned with the condition of the grade, the proper spacing of the ties, and the readiness of the ties to receive the rail. It is even possible that his concern extends to the location and intent of some of the more discontented Plains Indians. The gentleman is Samuel B. Reed, a Union Pacific construction engineer, one of Bob Brown's early predecessors. The picture is from the Union Pacific's collection. It has appeared in the Lucius Beebe and Charles Cleggs volume, "Hear the Train Blow."

Samuel Reed was constructing the Union Pacific Railroad west from Omaha, which began July 10, 1865. He and others who followed him on the Union Pacific

Fig. 1

have set a great tradition as track inspectors and as maintenance engineers; for the Union Pacific has long been noted throughout the industry for its sound track, a condition which can only be achieved from a maintenance program based upon a well conceived and developed inspection program.

More than 15 years earlier, the state of North Carolina became concerned as to the condition of one of its principal rail arteries, the Raleigh and Gaston Railroad, which connected its capital to the sea. Its interest derived from well-placed concern for the economic well being of both the railroad and the area which it served.

The Raleigh and Gaston, one of the early lines in the system of railroads which now comprise the Seaboard Coast Line, began construction in 1836 and was opened to traffic between Gaston and Raleigh on May 10, 1840. Gaston was a small community located near the fall line on the Roanoke River. Passengers and goods could there be transloaded to vessels for movement to the sea and coastwise to the entire eastern seaboard. Two other early lines in the present SCL system also reached Gaston: the Petersburg Railroad and the Portsmouth and Roanoke Railroad. The Raleigh and Gaston was an important link in the commerce of central North Carolina.

Thus, in September 1850, the Board of Commissioners of the Raleigh and Gaston, then the property of the state, ordered an inspection of its properties.

Major S. Moylan Fox, a civil engineer experienced in railway construction and maintenance, was engaged for the inspection. On December 16, 1850, Major Fox delivered his report to the Governor, and it was that day transmitted to the General Assembly. You may be interested in that part of the report which deals with the physical condition of the property. I quote from the report:

"The present condition of the structure of the road is very bad. The repair of the embankments and cuts of the road has been so much neglected that in nearly every case of the latter, the side ditches have not only been filled up, but the wash of the sides has collected in some instances as high as 5 feet above the bed of the road. The natural consequence of this is that the roadbed collects and retains all the water that falls, effectually preventing the road from ever being firm. All the embankments have been washed into ridges, and in many cases the top is scarcely wide enough for the bearing timbers of the road.

"The high embankments have settled from 1 to 3 feet below grade, increasing very much the actual steepness of the slope where an embankment occurs upon it. A large number of the drains and culverts are in a state of dilapidation; in several instances they are entirely washed away, together with the embankment which covered them. They will nearly all of them require rebuilding in whole or part.

"The water stations and wood depots are merely nominal, requiring an entire rebuilding or remodeling.

"The iron which was originally laid down, a light plate rail, has been so broken and crushed as scarcely to serve the purpose of a covering for the wooden rails—and in many places for several feet together, there is no iron upon the wood. The sleepers and stringers are about two-thirds of them good.

"The bridges require reflooring; in other respects they appear to be in good condition.

"In short, such is the entire dilapidation of this road that it is a matter of amazement that the officers should have been able to keep it in working condition."

His report went on to recommend a complete rebuilding of the road. He discussed the latest developments in road construction, drawing on both the British and the American experience. He estimated the cost of the improvements and the economic benefits to flow to the state and the railroad from the reconstruction. He stressed the advantages of the location of the line and its possibilities for future extension far south to Augusta, Ga.

Thus, you will observe, Major Fox, in his inspection and report, concerned himself with two important considerations in any track inspection—those conditions which mitigate against safety for continued operation and those which involve the ability of the road to remain an economic entity.

Following Major Fox's work, the state directed the reconstruction of the road. The reconstruction, as recommended, included a change from wood stringer and iron plate construction to a crosstie and "U" rail system. Earth work, bridge, and grade line improvements were undertaken.

Thus equipped, the Raleigh and Gaston moved into the future to become a principal heavy-duty line in SCL's important route connecting the northeastern United States, through Richmond, Va., to Birmingham, Ala., and the great and growing Southwest.

Since the days when Major Fox and Samuel B. Reed were making their important contributions to the development of the nation's rail system, the art of track inspection has grown and developed with the increasing speed of trains, axle loads of the cars and motive power, and growth of traffic.

Most of the early books of rules for guidance of maintenance of way officers and foremen contained rules and instructions on proper track inspections, and toward the turn of the century most roads had formal systems of inspection.

On August 15, 1898, W. M. Gwaltney, Jr., then chief engineer of the Seaboard Air Line Railway, issued a leather-bound book entitled "Instructions to the Roadway Department."

Track inspection was dealt with under the heading "Track-Walker," and I quote:

"Each day the foreman will carefully select and send an experienced and reliable man to walk over that portion of the section which he will not reach in person on that day. He should carry with him bolts and spikes, a wrench, a tamping pick, a red flag, and torpedoes in his pocket. He is expected to put in missing bolts, tighten loose nuts, replace broken spikes; to examine carefully all joints and rails, and to look for broken rails and burned joint ties, and to examine all switches, switch-locks and frogs closely. He must look for and put out all fences that are burning, and put up all fences that are down, close farm gates, and do everything he can to prevent stock from wandering on the track. He must remove all waste and other combustible matter from bridges and trestles as he passes over them.

"The most careful attention should be given to the switches by the foremen and track-walkers. They should work easily and have no lost motion. All switches should be kept lined up and to perfect surface at all times."

The concerns of the turn of the century are still important matters for today's track inspectors.

For years the track-walker was the first line of all track inspection programs. He was backed up by the frequent inspection of the section foreman and the roadmaster from, first, his lever car, and then from his motor car, and always his frequent riding of passenger and freight trains. This system of inspection persisted into the 1930's, well documented with books of rules.

Then technology began to take a hand. It was in this period that the need for a method of internal and non-destructive inspection of rails became plainly evident following serious derailments.

The United States Bureau of Safety, following a serious derailment in 1911, identified the cause as a failure of a rail, which James E. Howard, engineer–physicist of the Bureau, described as a "transverse fissure." In 1915 the Bureau began a series of experiments culminating in the development of magnetic rail defect detection equipment. While the laboratory work successfully located defects, efforts by the Bureau to translate this work to field inspection were unsuccessful. In the meantime, attention and instruction were concentrated on visual inspection of rail, often with the aid of a mirror for viewing the upper fillet. The ability to properly make visual inspections became a recognized highly respected art.

By 1923 this problem attracted the attention of an inventor, Dr. Elmer A. Sperry, who began development of an inspection car to detect presence of transverse fissures in rails while moving along the track.

The American Railway Association, predecessor of AAR, later contracted with Dr. Sperry to build a detector car and to develop and supply a rail testing service to the railroads. The Rail Committee of this association participated in and contributed to this work. The reports of Committee 4—Rail, particularly Volumes 19 through 24 of the Proceedings, reflect the early work.

The initial work with magnetic detection done by Dr. Sperry under the ARA contract did not produce a satisfactory test unit, and he began investigation of an entirely new principle, the induction method of detection. It was from this work that the present Sperry equipment evolved.

The ARA and the AAR continued to work with magnetic testing and developed equipment which would satisfactorily test rails for internal defects. It established a testing service for Member Roads.

As a result of these efforts on the part of Sperry and AAR, most of the rail on the main-line trackage of the nation was placed under internal inspection.

About the same time, some individual railroads began experiments with equipment to measure and record the gage, line, and surface of track while moving in trains. This equipment was generally mounted in a rebuilt passenger inspection car. An important use was to grade the track of individual supervisors as a spur to superior performance, as well as to aid in the development of system maintenance programs.

Through the war years of the 1940's, the 1950's and into the 1960's, track inspection increasingly became the direct responsibility and duty of the roadmaster or track supervisor, assisted by designated inspectors who patrolled the track on motor cars, equipped with tools for minor repairs. Gradually the track-walker all but disappeared.

The use of cars equipped for measurement of line, surface, gage and warp, or collectively, track geometry, came into more general use. Several models of self-propelled cars are offered or under development to determine and record track geometry.

More sophisticated equipment mounted in rail cars is capable of making track measurements at high speed in train service. These are equipped with computers which, on a real-time basis, print out data for decision making. Those of you from Southern Railway are, of course, familiar with this type of equipment in use on your line.

Thus, traditionally, long before these days of federal track inspection standards, railroads laid great stress on, and performed, an adequate inspection of their properties.

This self-motivation continues to be essential to the railroads' well being in this new age of the FRA standards.

It was recently my privilege to observe at first hand track geometry equipment owned by the Federal Railroad Administration, which includes some of the latest developments in track measurement. This equipment was first developed in connection with the Northeast Corridor Project to evaluate contract compliance.

The FRA cars were operated on June 20 and 22, 1972, between Orlando and Opa-Locka, Fla., to collect track geometry on the Seaboard Coast Line's main track. The data was to be used in an evaluation of the track in connection with its possible use in a turbo train demonstration project.

I will not attempt a detailed description of the equipment. This information is available in a series of reports prepared by and available from FRA. Operation of the equipment is discussed in an address, entitled Automated Track Inspection and Its Uses, presented September 20, 1970, at the annual meeting of the Roadmasters' and Maintenance of Way Association by Thomas P. Woll of FRA. It appears in the proceedings of the 82nd Annual Convention.

Mr. Woll has made available to me slides of the equipment.

(Text continued on page 374)

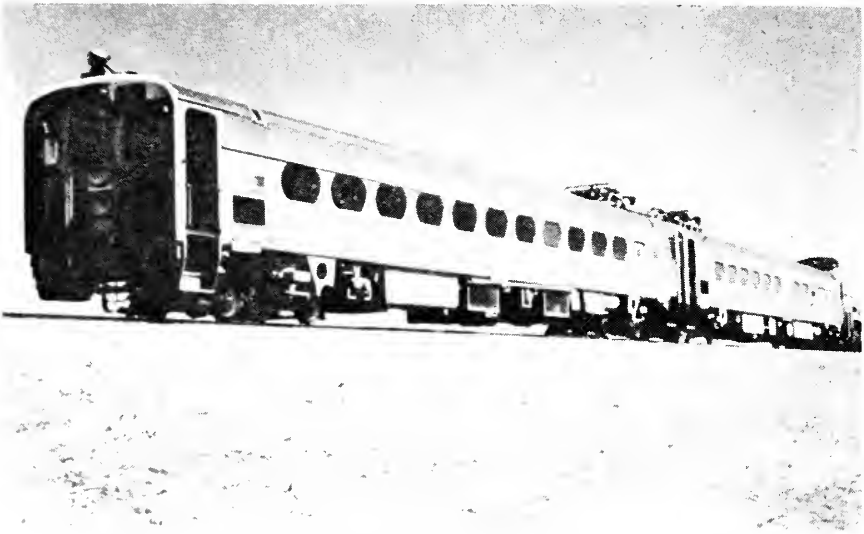


Fig. 2—Consist of the FRA test equipment. The cars are designed to operate in pairs, and at speeds of up to 150 mph. The cars are electrically self-propelled, taking power from the catinary system. They may also be operated with locomotives. The cars each weigh approximately 100,000 lb.

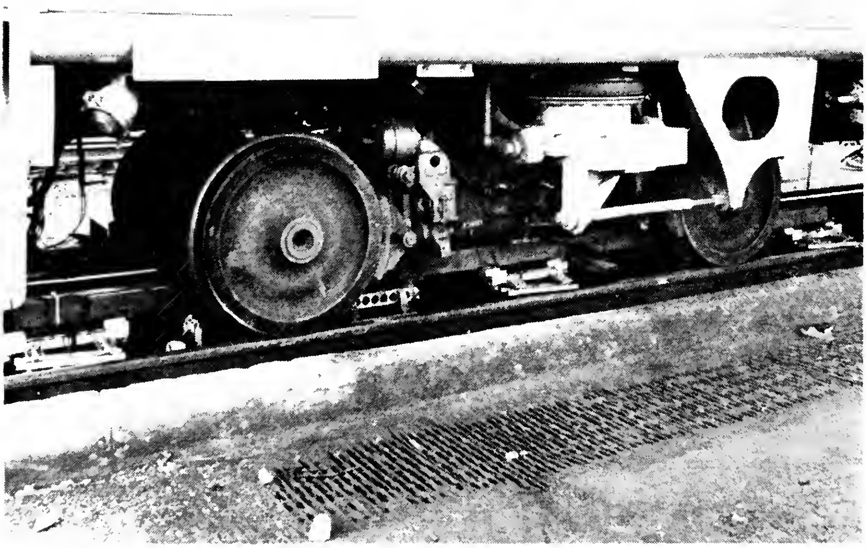


Fig. 3—Specially designed proximity sensors in the track geometry system, which operate on a capacitance principle and permit measurement of loaded track geometry. They are deployed on a 14.5-ft beam rigidly mounted on the truck axles. To the left center and right are profile and alignment sensors with the gage sensors near the right wheel.

Fig. 4—An underview of the sensors.

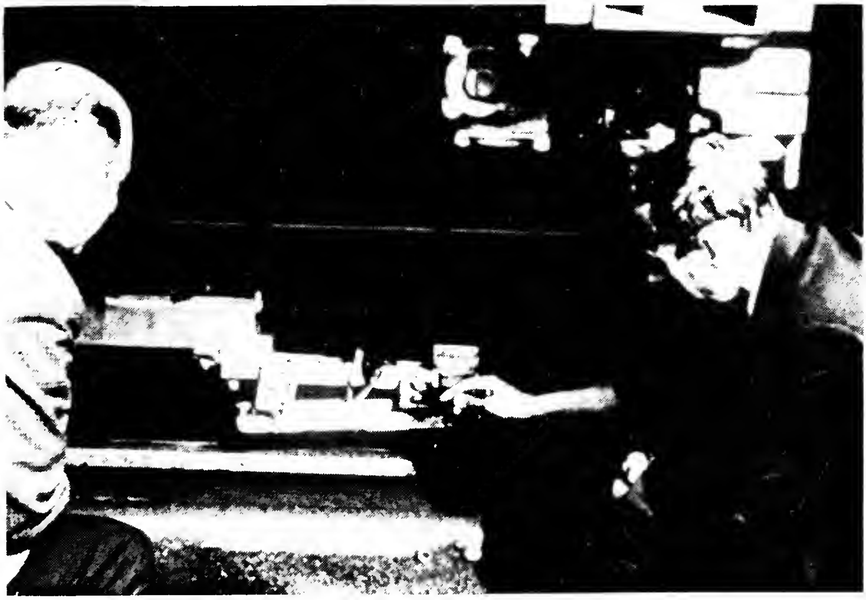


Fig. 5—Closer view of one of the sensors.

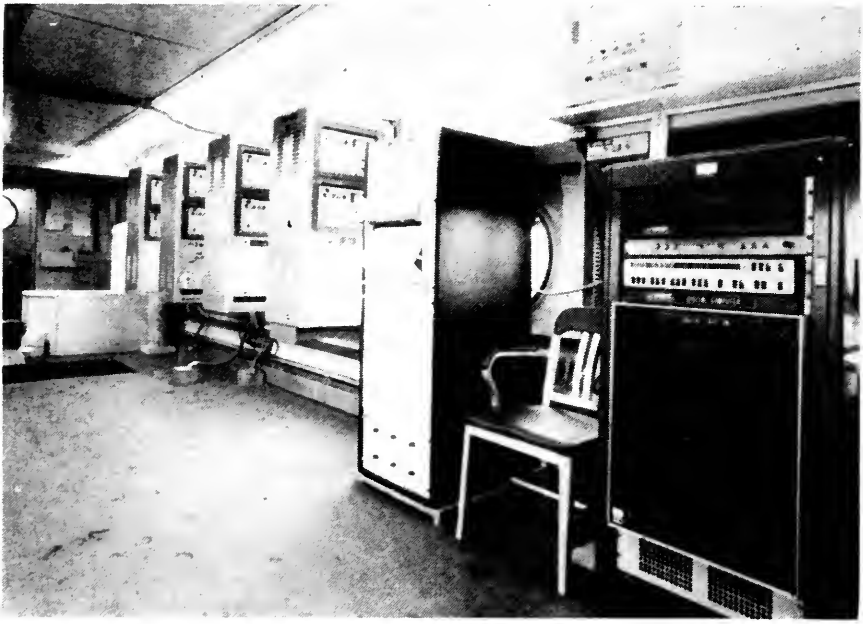


Fig. 6—Instrumentation for collecting, recording, and digital computer processing of the data.

Thus, track inspection has, since the beginning, been the keystone of maintenance programs. Track maintenance officers have, from the earliest days, considered it to be the most important facet of their work. It has grown in depth and complexity with the increase in speed, axle loading, and traffic density.

Its ultimate purposes, however, have remained the same.

The first and most important purpose of track inspection is to insure the safety of the people, equipment, and goods moving over the rail system. The second purpose is to preserve the fiscal integrity of the railroad which owns and operates the track.

To determine when the needs of operational safety have been met, the inspector was formerly guided by those elements of track geometry set down by the individual railroads in books of rules and other instructions for standards and tolerances. The FRA Track Safety Standards were developed from a review of many individual railroad standards: from a review of the work of this Association, and the Engineering Division, AAR; and from discussions with railway labor, governmental bodies, and other interested groups.

These standards, adopted as minimum safety requirements for railroad track which is a part of the general national rail system, are to be used as a guide to determine by inspection if track is safe for movement at the designated speeds.

It is well to recall that the standards for the individual road are not set aside by these minimum standards, they still apply.

When the inspector has determined that the needs for safe operation have been met, he then must turn to the more difficult phase of his assignment: that of seeing

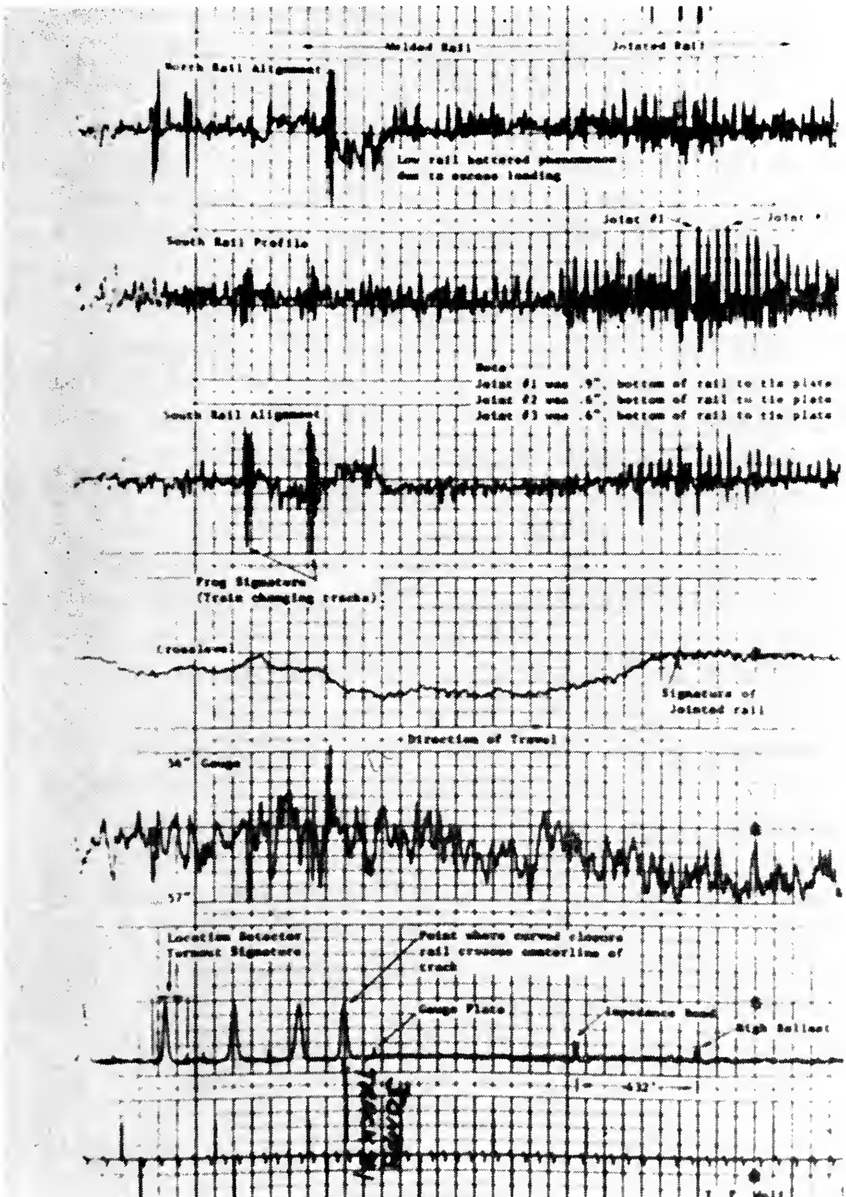


Fig. 7—Analog chart recording of track geometry produced by the car. Incidentally, this data was taken near Andover, Md., on the Northeast Corridor Project, at a location where the track changes from jointed to welded construction. The jointed section is shown in the right third of the chart.

to it that the resources of the company allocated to maintenance of the track are employed in the manner which will result in the greatest improvement to the system as a whole. At the same time, he must do his work within the income which the regulated rates and the current level of economic activity will produce for his company.

This process involves the interaction of people at all levels within the maintenance department. It begins with the track foreman and the roadmaster. It extends to division and system supervision, and for most railroads includes the chief executive officer of the company, for all are involved not only in visual inspection, but also in the decision-making process which logically follows.

Even with the increasing use of technology in track inspection, it is with the man who is daily on the track that both the physical and financial safety of the company rests. It is he who must, in the final analysis, interpret and act upon the results of inspection and apply resources of manpower and materials which will result in proper maintenance for safe operation and preserve the economic well being of his company.

Thus, the inspection itself, whether visual, by riding, or walking, whether made by detector car or track geometry car, is only the first step in the process of daily decision-making, that of getting the facts.

With the facts at hand and presented in usable form, the second phase of the decision process is invoked, that of determining what standards and rules apply, both from the new federal rules and regulations and from the company's own standards and procedures. Due consideration must be given to the resources available to carry out the work, always giving consideration to the property as a whole, and its continuation as a viable part of the national rail system.

When these conditions have been satisfied, then is the time to take action—to assign materials and manpower to the work, and to pursue it in the most economical manner.

The final step in the process for the inspector is that of checking the results of the decision made and the action taken. At this point the process comes to full circle.

This continuous follow up is as important as the initial act of inspection.

The Railroad Man of Tomorrow

By J. B. CLARK
Assistant Vice President—Personnel & Labor Relations
Louisville & Nashville Railroad

How could anyone resist the temptation to deal with the subject of any "Man of Tomorrow"? Especially, how could a railroad man resist the temptation to deal with the subject of THE RAILROAD MAN OF TOMORROW?

The mere question of "What is Tomorrow?" is worthy of some thought. My granddaughter, shortly after her third birthday, was entranced by pictures of her mother's wedding, and in the pictures she saw her cousin, who was four years old at the time the picture was taken and was dressed in a long skirt to serve as flower girl. The picture appealed to her so much that she said, "Tomorrow I will be four years old and have a long dress and be in my mother's wedding and sing and dance." So, for her, the term "Tomorrow" meant the indefinite future. I am willing to take that definition of tomorrow.

As youngsters we all engaged in fantasies, most of which dealt with the future and what the future might hold in store for us. Can you think back on those daydreams and remember what you thought the future would be like? Have you, as I have, found that the degree to which we missed the predictions for the future was dependent to some extent upon the length of time since we had those childish dreams and the present, and probably also upon the environment in which we made our dreams for the future. In my own case, I missed the prediction about the future by a mile, at least in regard to the material things that would be attainable by me and my contemporaries.

There are so many material things available to the ordinary citizen of this country now that were not in existence in those days that the average person now has possessions that would put my childish dreams to shame. Perhaps my missing the expectations of the future by such a great degree can be excused by the fact that I was looking into a world with which I was not familiar and in which I had no experience. If the predictions I make today about The Railroad Man of Tomorrow should miss the mark so widely, I will not have the same excuse.

Certainly The Railroad Man of Tomorrow will be one who can live successfully in his environment—that is, one who can live successfully in the railroad industry as it will be tomorrow. What then will the railroad industry be like tomorrow? We can feel sure that there will be railroads tomorrow, for there is no other method of transportation available now or in the foreseeable future that can handle the diversity and quantity of materials with the same degree of efficiency in the use of labor, material, and natural resources—and with as little effect on the ecology of the country.

In order to be in existence "Tomorrow," the railroad industry as we know it today will have to solve the problems of today and tomorrow. The physical plant must be kept in proper condition. The consumable and depreciable property must be replaced on a current basis. The property must be improved and extended to meet the demands of the public and competition and to serve the newly developed areas so that the basic function of moving raw materials and manufactured goods from the point where it exists to the point where it is needed can be performed.

Service must be provided in the most economical way possible in order to keep the overall cost of products at a level that will make it possible for them to be purchased by the largest possible number of people. The problems of discriminatory taxation, inflation resulting in increased labor rates and material costs, outmoded labor laws and regulations, must be met by The Railroad Man of Tomorrow. Collectively, the Railroad *Men* of Tomorrow will have the task of:

— Increasing revenues;

— Improving service;

— Setting rates at a level low enough to attract business and high enough to yield a reasonable profit;

— Eliminating unneeded facilities so as to avoid drain on the resources of the industry, yet not imperil national security;

— Increasing productivity of capital, equipment and labor;

— Eliminating archaic work rules and generally maintain good labor relations;

— Following good employment and personnel practices.

— Developing management teams;

— Budgeting expenditures so as to keep the physical plant viable, meet the payroll, pay taxes, pay for materials, and retain enough income to pay off the debt, pay for necessary improvements and expansions, pay a reasonable dividend to the owners of the property, and generally maintain an economic condition that will inspire capital investment by the general public; and finally

— Performing efficiently at all levels of employment.

Obviously, every Railroad Man of Tomorrow has a formidable task before him, especially the Railroad Man of Tomorrow who holds a management position at whatever level. He must be conscious of and conversant with current events of world, national and local interest; he must be able to see how the railroad can fit into the demands of the section of the country it serves. He must be adept at handling the resources at his command and must see that the public and the legislative bodies are aware of the railroads' accomplishments and their problems, and especially of their essentiality.

Perhaps the change that is most urgently needed to aid in the performance of several of the tasks previously mentioned is the need to improve the railroad industry's image. An improved image would make it easier to increase revenues, which may be the most important task of The Railroad Man of Tomorrow. Conversely, the proper performance of several of the tasks would go a long way toward improving the railroad industry's image. For instance—if railroad men at all levels of employment perform efficiently, if service is improved and good employment and personnel practices are followed, the image of the railroad industry is bound to be improved. In other words, good performance by the railroad industry will improve that industry's image and a good image will make it easier for the railroad industry to give a good performance. It seems to follow, then, that the railroad industry should play up its good performances in whatever areas they may be.

The public too often has over-simplified a complex problem in this complex industry of railroading. A great many members of the general public, even some legislators, recommend over-simple solutions to the railroads' problems. Probably each one of you has heard a suggestion that the railroads could be revived if they would only put on good passenger trains with frequent service, good dining cars, and run their trains at high speeds. Those same people overlook the fact that many railroads had just such service and that the public abandoned that service in favor of the family automobile.

However, in spite of such clear evidence as was contained in a recent report by John D. Williams in the *Wall Street Journal*—headed "People Like Trains But Don't Ride Them, Amtrak Survey Finds—A $200,000 Harris Poll Reports 82% Want Option to Travel by Rail But Only 4% Use It"—advocates of the theory that good passenger service will solve all the railroads' problems frequently are willing to assign any responsibility for the failure of railroads to prosper to their not being willing to accept what they think is such a simple solution to the problem. This simple example of the general public's misunderstanding of the railroad industry's situation may in itself be an over-simplification. However, it is true that many members of the general public associate railroading with passenger trains and conclude that, since there are fewer passenger trains operating each year, the railroad industry is just about to go out of business.

That feeling was depicted recently in a cartoon in a usually conservative paper that showed a real estate salesman talking to a couple of prospective buyers, very blithely stating: "Since the Trains Have Stopped Running, Mrs. Witherspoon, There Is No Wrong Side of the Tracks Anymore."

Other pat solutions to complex problems have been adopted by the general public and in some cases by several segments of the railroad industry itself. For instance—a few years ago, when it appeared to me that the public was finally becoming aware of the railroads' problems as well as some of its accomplishments, the climate for mergers became better and there were those who vied with each other in suggesting larger and larger mergers so as to result in a raiload system in the United States comprised of fewer and fewer companies. About the same time, others vied with each other in suggesting larger and larger cars. It was assumed that, if material could be hauled with greater efficiency in 70-ton cars than in 50-ton cars, then it could certainly be hauled more efficiently in 100-ton cars, and even more efficiently in 150-ton cars, ad infinitum. Experience has shown that, while some well-planned mergers resulted in substantial savings by the elimination of duplicate services and facilities, the mere merging of two or more railroads was no panacea, but in some cases created more problems than they solved; similarly, the introduction of bigger and heavier equipment also created problems that need to be solved before the efficiencies that were predicted will be obtained. Witness the present problem of train-track dynamics. These examples are cited to show that there is no *easy* solution to all complex problems. It is not intended to suggest that there are *no* solutions to those problems.

Perhaps throughout the years we have dwelled on so many problems of the railroad industry one at a time to have caused the general public to come to the conclusion that our problems are so great and varied, or at least so greatly beyond our ability to cope with them, that there is little hope for the railroad industry to survive. Perhaps we have led the public to their way of thinking by concentrating on one basic problem at a time or on one accomplishment at a time. It may be like the case of the engineer who was bombarded by a program during the steam engine days of conserving cylinder oil. This particular railroad in the story had inaugurated a program to conserve cylinder oil and had worked up many figures showing that saving a drop of oil each time the oil can was used would amount to so many drops per day by all of the engineers on the railroad, so many gallons per week, so many gallons per month, so many gallons per year, amounting to so many dollars that the engineer finally became impressed with the fact that if he could only conserve cylinder oil, he could make the railroad rich. On his way to a rules examination class he was stopped by the road foreman of engines and given yet another pep talk on conserving oil. The first question he received in the discussion of the rules was, "What would you do if you were on single track going north and you looked up and saw an engine approaching you coming south at high speed?" The engineer unhesitatingly said, "I would grab the oil can and jump off."

We should dwell more on the many accomplishments of the industry and with our success in handling many of the problems so that the need we have for help in solving the remaining problems can be accepted by the public. For instance:

— We can show that the movement of freight can be performed by railroads with less damage to the ecology of the country than any other mover of mixed types of commodities.

— We can show that we have contributed less toward the inflation in this country than probably any other industry. Our revenue per-ton-mile increased only from 1.40 cents in 1960 to 1.43 cents in 1970. This was true in spite of the fact that the railroad industry had to bear the burden of increased cost to it in the form of inflation for material and labor.

— We can show the progress that has been made in the field of engineering and maintenance, including the more effective use of men, materials and equipment, the improved method of establishing priorities on work that needs to be done, and the improved systems of programming the work.

— We can show that there have been several rail mergers that have resulted in the benefits to the industry and public that were anticipated.

— We can show that we have made significant progress in the past two years in removing some of the restrictions of archaic work rules. For instance, agreements have been reached designed to reduce the number of locomotive firemen to the number needed for training to become locomotive engineers and agreements have been reached that will combine the work of clerks and telegraphers into one craft, thereby eliminating one craft.

— We can show that the railroads can and do haul freight at less total combined cost to the individual user and general public than any other form of transportation engaged in the movement of mixed types of commodities.

— We can show that the railroad industry handled more ton-miles of freight in 1969 than in any other year in the history of the United States, including the peak years during World War II.

— We can show that the railroads have the capacity to move a much higher volume of traffic than they are now moving.

If the public could be made to recognize the accomplishments that have been achieved by the railroad industry, our task of interesting the public in aiding us in getting the much needed revisions in outmoded laws and regulations in such fields as labor and taxations should be considerably easier.

The improvement of the railroad industry's image, like the other proposed solutions to the railroads' problems, will not in itself cure all of its ills; however, it will improve our ability to attract the right kind of individuals to be the RAILROAD MEN OF TOMORROW and to perform the tasks outlined earlier as a requirement for the Railroad Men of Tomorrow collectively.

In his book, "Struggle for Identity: the Silent Revolution Against Corporate Conformity," Roger M. D'Atrix, an employee relations specialist at Xerox Corporation, had quite a lot to say about the human needs of employees. He stated that employees "need to be recognized as members of a human community and as contributors to it . . . they need to feel reasonably fulfilled in their work . . . they need to be dealt with as intelligent and mature human beings who can be trusted to contribute to goals they understand." He also says, "The fundamental problem with our organization today is the absence of the all-important feeling of belonging to a worthwhile enterprise where one can grow and contribute, where one can feel he is part of a cause to which he can dedicate his talents and energies."

We should have no problem in establishing or reestablishing the fact that the railroad industry is truly one of the most essential, if not *the* most essential, in the United States. What industry could be more worthwhile or essential in these United States than the one that performs such tasks as moving coal, limestone and iron ore to a common point where steel can be manufactured and then moving the steel to points where it can be converted into worthwhile machines, and then moving those machines to points where they can be used in the manufacture of essential goods, and then moving those goods to the points where they can be used by the consumer?

Having established or reestablished the importance of the railroads and the railroad men in the minds of the public, the task of recruiting the best type of new employee possible and of motivating employees to perform to their capacities and to accept the responsibilities of higher positions should be considerably easier. The recruiting and selection of new employees to become The Railroad Men of Tomorrow and the motivation and selection of Railroad Men of Today to become railroad managers of tomorrow is one of the most important duties of the railroad manager of today. On every railroad in the country the expense for wages and salaries is more than for any other item of expense. It is apparent that such an important item deserves even more consideration than the selection of the proper locomotive, tie tamper, or tie renewal machine.

In review, the Railroad Man of Tomorrow must be capable of living successfully in his environment and of solving the problems of today and tomorrow. He will be what the railroad man of today makes him.

Who will be the Railroad Man of Tomorrow? He will be the railroad man of today with improvements and growth that he attains between now and tomorrow. He will also be the man the railroad man of today selects with improvements and growth that he attains between now and tomorrow. In speaking of growth of individuals, I am reminded of the quatrain by Edward Markham, which might be considered a challenge to the railroad man of today to grow and select men for the railroad industry of tomorrow who can and will grow . . . and to help them in that growth. Markham says

"Why build these cities glorious
If man unbuilded goes?
In vain we build the world,
Unless the builder also grows."

Railroad Subgrade Stresses

By HERBERT O. IRELAND

Professor of Civil Engineering, University of Illinois at Urbana–Champaign

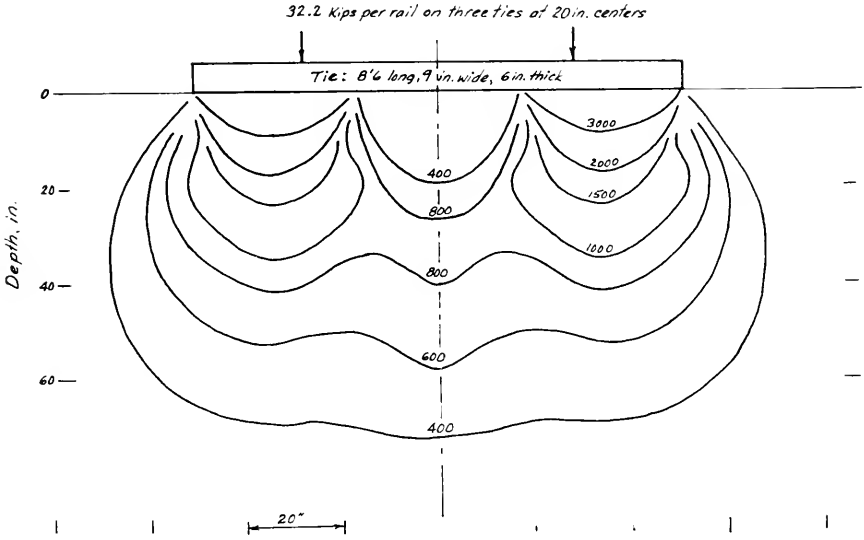
When I was first contacted about participating in this program, our Chairman, Mr. Kelso, suggested that I might discuss the general problem of roadbed stabilization as far as railroads are concerned. Inasmuch as I made a presentation at the 1970 AREA Convention in Chicago on the subject of soil stabilization, which has been published in the proceedings (Volume 71, 1970—Bulletin 628), I thought it might be more appropriate to discuss the general subject of stresses in the subgrade and their relationship to roadbed stability.

The stresses that reach a railroad subgrade depend upon the traffic loads distributed through the rail, the ties, and the ballast section. This represents a relatively complex structural system involving various load configurations, rail weights and properties, tie dimensions, tie spacings, and their physical properties in order to determine the stresses at the contact between the bottom of the ties and the ballast section. Pioneer work on the problem of the transmission of pressures in ballast was done by A. N. Talbot and others and reported in the AREA Proceedings of 1920. They developed an equation, $P_c = 16.8\ P_a/h^{1.25}$ where P_c is the pressure at depth h beneath the center line of a tie with an average contact pressure of P_a. This equation is based on experimental data and is limited to depths of between 4 and 30 inches beneath the base of the tie as it was considered to give values that are too high beyond these limits. The results of Talbot's work have been in general use and are mentioned in the latest revision of the AREA Manual Section on Roadbed.

Although the ballast section performs several important and well defined functions, in this discussion the transmission of the load of the track and traffic to the subgrade is of particular interest. With inadequate ballast, the ties tend to sink unevenly under the concentration of load because of the inability of the subgrade to support them. In a relatively impermeable subgrade, the resulting depressions act as collecting basins for water which may further soften the subgrade and initiate the conditions that lead to pumping. An important function of the ballast, which ideally has a high friction angle, is to directly support the relatively high pressures at the base of the tie.

If it is assumed that the ballast and subgrade below the ties is completely elastic, the distribution of vertical pressure beneath the ties can be determined using Newmark's graphical solutiton of the Boussinesq theory. The distribution of vertical pressures beneath the ties for one case is shown in Fig. 1. This is based upon certain assumptions. It is for an ore car with a gross weight of about 257,600 lb (a capacity of 95 long tons) or about 32.2 kips/wheel. In preparing this figure, it was assumed that 1 axle would be supported by 3 ties and that each rail would load the outer 1/3 of the tie. It is for ties 8 ft 6 inches long, 9 inches wide, 6 inches thick, spaced at about 20 inches center to center. The load at the bottom of the outer third of the ties is about 5,000 lb/sq ft.

To use Newmark's procedure, it is necessary to prepare plan drawings of the loaded areas to a scale that is a function of the depth where the pressure is desired and the scale of the particular influence chart being used. There are no depth limitations to the application of this method. It is readily available in many books on

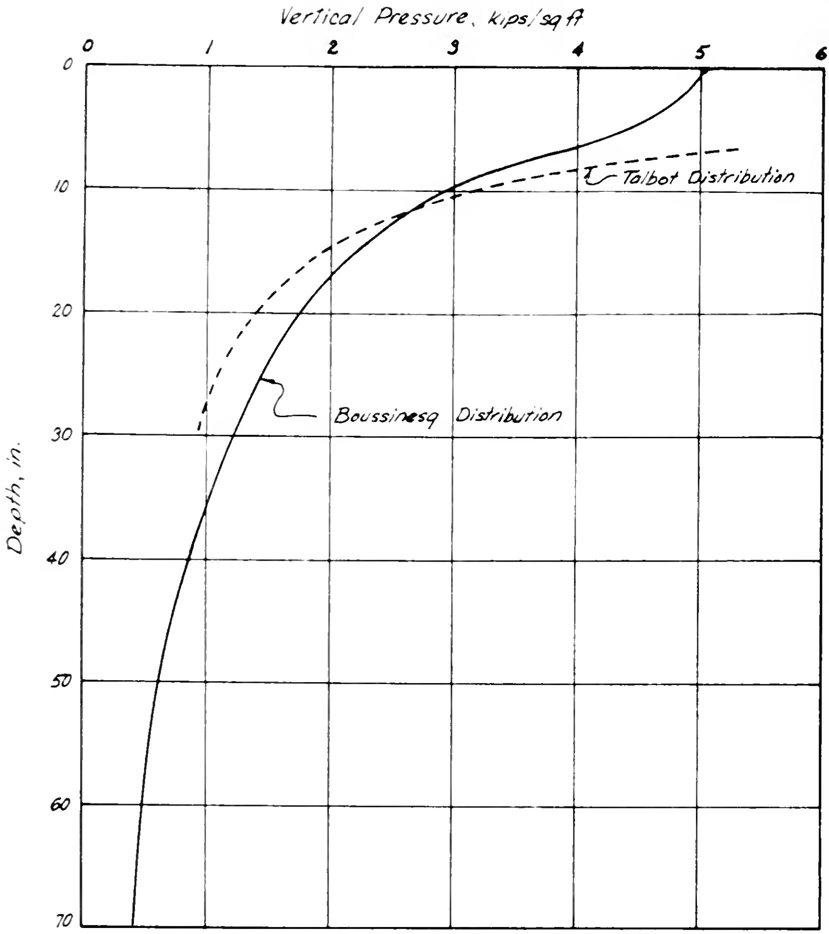


Approximate Distribution of Vertical Stresses Beneath Ties
Fig. 1

soil mechanics and foundation engineering, for instance, Terzaghi and Peck, "Soil Mechanics and Engineering Practice." The method includes the overlapping influence of adjacent loaded areas which may be of some significance at lower depths. Fig. 1 includes the influence of an adjacent axle. If the maximum vertical stress beneath the tie is plotted versus its corresponding depth, a diagram such as Fig. 2 can be obtained. The corresponding distribution obtained from Talbot's equation is shown for comparison. There has been no attempt to explore the variations in the Boussinesq pressure distribution associated with other assumptions as to the distribution of the wheel loads through the track and tie structure.

This example is based on static loads only and does not consider dynamic effects. According to some pressure cell observations in track made by the AAR research staff in the early 1950's, the impact effect of dynamic loads increased the recorded static soil pressures by about 50% for a diesel locomotive. The pressure cells were located 4 ft below the bottom of tie.

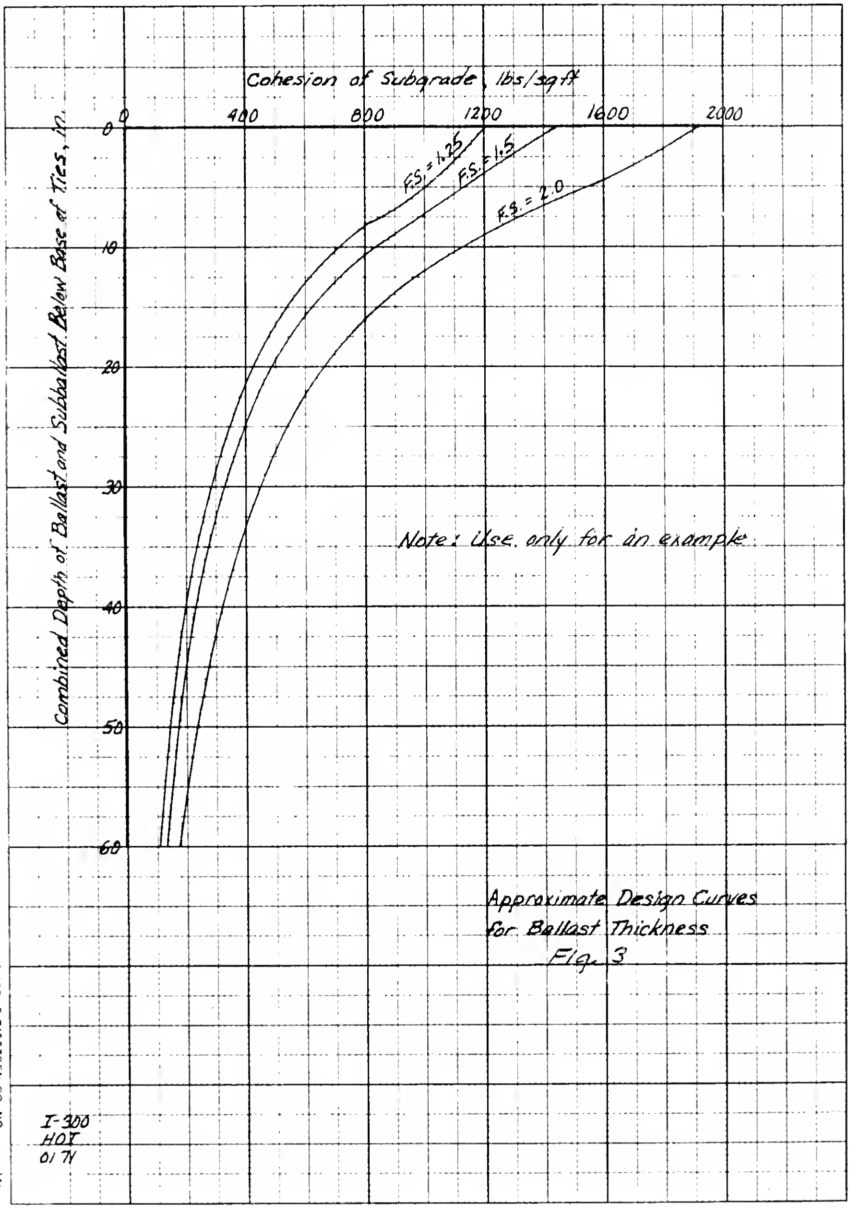
To prevent a bearing capacity failure or undue creep beneath a loaded area, the level of the stress in the subsoil should not exceed an allowable bearing pressure based upon a suitable factor of safety. In my opinion, it is desirable to maintain a factor of safety of at least 2, but sometimes economics dictate that a lower factor of safety must be considered. Under no circumstance should the factor of safety be less than 1.5 unless a certain amount of creep and deformation is acceptable. The allowable bearing pressure of a cohesive subgrade may be taken as $5c/F$ where c is the undrained shear strength (cohesion) of the soil and F is the factor of safety. This is most applicable to clayey soils where low strength problems can be anticipated. We seldom have bearing capacity problems in sands. Ideally, the



Distribution of
Maximum Vertical Stresses Beneath Tie
Fig. 2

saturated undrained strength should be used because this probably represents the minimum strength that is likely to exist in the field and therefore should be the basis for design. In many instances, it is probable that where free water is available the strengths will deteriorate as a function of time and volume of traffic.

The relatively high stresses beneath the ties within a depth of about 10 to 20 inches are generally located within the ballast section. Design curves of required ballast thicknesses for various factors of safety with respect to the subgrade may be prepared as illustrated in Fig. 3. To construct such ballast thickness design



Approximate Design Curves for Ballast Thickness
Fig. 3

curves, the allowable bearing capacity (for a given subgrade shear strength and a selected factor of safety) is plotted at the depth where that stress level occurs as shown in Fig. 2. In other words, a sufficient thickness of ballast is required to distribute the tie loads so that the stresses at the base of the ballast section do not exceed the allowable bearing capacity of the subsoil at that location.

If the factor of safety is significantly less than 2, some creep can be expected. This causes settlement of the entire ballast section and contributes to requred track maintenance. If the factor of safety is too low, a failure is inevitable.

Good practice requires a minimum of 6 inches of subballast, ideally a relatively fine-grained granular material that is most valuable in preventing or minimizing pumping action and the penetration of ballast into the subgrade. In reality, a fouled ballast condition occurs when the subgrade materials work their way up through the ballast to the base of the tie. In view of its benefit, new track should not be constructed without providing a subballast of suitable gradations. If properly sized, the subballast should be fine enough so that subgrade materials cannot penetrate into it and coarse enough so that it will not penetrate into the ballast section. The principle is that of a graded filter. The subballast should be considered as a part of the ballast section in transmitting stresses to the subgrade.

Various techniques have been used in attempts to stabilize roadbeds. These include many types of drains, cement grouting, pole driving, sand filled wells, and miscellaneous other techniques. More recently, lime is being used in stabilization programs on several railroads. If a stabilization program is successful, it either eliminates excess water, increases the overall strength of the subgrade, or reduces the level of stresses reaching the subgrade. New construction should be planned to obtain a relatively high subgrade strength with a ballast section consisting of at least 12 inches of ballast and 6 inches of selected subballast placed on a crowned subgrade to facilitate drainage.

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AMERICAN RAILWAY ENGINEERING ASSOCIATION
72nd ANNUAL CONVENTION

ENGINEERING DIVISION
ASSOCIATION OF AMERICAN RAILROADS
1973 ANNUAL MEETING

MARCH 19–21, 1973
Palmer House, Chicago

PROGRAM

MONDAY, MARCH 19

Opening Session—Red Lacquer Room (4th Floor)—0930 to 1200

Invocation—Dr. Kenneth Hildebrand, Pastor, Central Church of Chicago

Recognition of speakers table guests

Presidential Address—Robert M. Brown, Chief Engineer, Union Pacific Railroad

Report of Treasurer—Arthur B. Hillman, Jr., Chief Engineer, Belt Railway of Chicago

Report of Executive Manager—Earl W. Hodgkins

Greetings from Railway Engineering-Maintenance Suppliers Association—Richard G. Wade, President

Address—John W. Ingram, Administrator, Federal Railroad Administration, U. S. Department of Transportation

Addresses—Engineering and Maintenance Practice of European Railroads (Illustrated)

SPEAKERS

John G. German, Assistant Vice President–Engineering, Missouri Pacific Railroad (England, France, Germany, Austria, Switzerland)

George Pipas, Vice President, Communications and Computer Services, Illinois Central Gulf Railroad (Russia)

William S. Autrey, Chief Engineer, Atchison, Topeka & Santa Fe Railway (Austria, England, France, Germany)

Engineering Division Session—Red Lacquer Room—1330 to 1730

Recognition of speakers table guests

Remarks by Chairman Robert M. Brown

Report of General Committee—Executive Director Earl W. Hodgkins

Remarks—R. Rex Manion, Vice President, Operations and Maintenance Department, AAR

Remarks—Dr. William J. Harris, Jr., Vice President, Research and Test Department, AAR

Address—Milton Klein, Associate Administrator for Research, Development and Demonstrations, Federal Railroad Administration

Bulletin Number

Report—AREA COMMITTEE 28—CLEARANCES 640

Address by L. R. Beattie, Assistant Engineer, Atchison, Topeka & Santa Fe Railway—Near Misses Make Money (Illustrated)

Addresses—Programs and Projects of the AAR Research Center (Illustrated)

SPEAKERS

H. I. Dwyer, Jr., Director, Research Center—Opening Remarks and Introductions

K. W. Schoeneberg, Executive Research Engineer, and D. H. Stone, Research Metallurgist—Rail Research Programs

E. F. Lind, Project Director, AAR-RPI Research Program on Track-Train Dynamics—Track-Train Dynamics Program

W. C. So, Research Engineer—Track Lateral Stability Program

G. C. Martin, Senior Research Engineer—Track Research Programs

TUESDAY, MARCH 20

General Session—Red Lacquer Room—0830 to 1130

Reports of Committees — Bulletin Numbers

15—STEEL STRUCTURES .... 640 & 641

Addresses—Remote Control of Movable Bridges (Illustrated)

SPEAKERS

H. L. Chamberlain, Engineer of Structures, Missouri Pacific Railroad—Railroad Problems on the Arkansas River Navigation Project

A. E. Schmidt, Project Engineer, Sverdrup & Parcel and Associates, Inc.—Development and Design of Remote Control Systems for Movable Bridges

7—TIMBER STRUCTURES -- 641

8—CONCRETE STRUCTURES AND FOUNDATIONS ---------------------- 640 & 641

Address—Dr. D. W. Goodpasture, Associate Professor of Civil Engineering, University of Tennessee—Full Scale Tests to Failure of Four Highway Bridges (Illustrated)

6—BUILDINGS -- 640 & 641

Address—J. H. Seamon, Manager, Railroad Research Information Service, National Research Council—The Railroad Research Information Service—What It Is and How It May Be Used (Illustrated)

11—ENGINEERING RECORDS AND PROPERTY ACCOUNTING -------------- 640

24—ENGINEERING EDUCATION ---------------------------------- 641

Address—Dr. B. M. Davidson, Academic Dean, U. S. Naval Academy—Have We Been Railroaded by Education?

ANNUAL LUNCHEON—GRAND BALLROOM—1200

Presentation of those at speaker's table

Presentation of those at committee chairmen's table

Announcement of election of officers

Address by John C. Kenefick, President, Union Pacific Railroad

General Session—Red Lacquer Room—1400 to 1730

Reports of Committees — Bulletin Numbers

9—HIGHWAYS -- 640

Addresses—A National Data System for Grade Crossing Safety (Illustrated)

SPEAKERS

O. F. Sonefeld, Transportation Specialist, Office of Policy and Planning, Federal Railroad Administration

H. A. Richards, Research Economist, Texas Transportation Institute

M. R. Sproles, Executive Director, Highway-Rail Programs, AAR

13—ENVIRONMENTAL ENGINEERING 640

Address—J. R. Coxey, Assistant to Vice President and Manager, Environmental Studies Division, AAR—Impact of 1972 Pollution Control Act on Railroad Operations

25—WATERWAYS AND HARBORS 641

30—IMPACT AND BRIDGE STRESSES 641

Panel Discussion—ASTM A588 Steel for Railroad Structures (Illustrated)

PANEL MEMBERS

L. N. Bigelow (Moderator), Senior Staff Engineer, American Bridge Division, United States Steel Corp.

K. H. Klippstein, Senior Research Engineer, USSC Research Laboratory—Fatigue Testing Under Variable Amplitude —Random Sequence Loadings

J. M. Barsom, Associate Research Consultant, USSC Research Laboratory—Some Aspects of Fatigue Behavior of Steel

R. L. Mion, Industry Representative, Construction Marketing, USSC—Practical Applications of A588 Steel

P. E. Masters, Chief Welding Engineer, American Bridge Division, USSC—Review of Welding Processes and Quality Control by Non-Destructive Testing

22—ECONOMICS OF RAILWAY CONSTRUCTION AND MAINTENANCE .... 639 & 640

14—YARDS AND TERMINALS .... 639 & 640

Address—P. J. DeIvernois, Jr., Senior Consultant, Union Switch and Signal Division, WABCO—Evolution of Control Systems in Retarder Yards (Illustrated)

Address—A. V. Dasburg, Manager Customer Service, General Railway Signal Company—50th Anniversary of the Car Retarder (Illustrated)

WEDNESDAY, MARCH 21

General Session—Red Lacquer Room—0830 to 1300

4—RAIL 641

Address—W. S. Lovelace, Assistant Manager. Research & Tests, Southern Railway System—Recent Developments in Rail Joints and Adhesive Bonding Techniques (Illustrated)

31—CONTINUOUS WELDED RAIL .... 640 & 641

5—TRACK .... 640 & 641

27—MAINTENANCE OF WAY WORK EQUIPMENT 641

Address—T. R. Ringer, Section Head, Cold Temperature Laboratory, National Research Council of Canada—Thermal Protection of Track Switches (Illustrated)

1—ROADWAY AND BALLAST .... 640 & 641

16—ECONOMICS OF PLANT, EQUIPMENT AND OPERATIONS .... 639 & 640

Address—A. L. Sams, Vice President and Chief Engineer, Illinois Central Gulf Railroad—Impact of Revised Track Safety Standards of Federal Railroad Administration

3—TIES AND WOOD PRESERVATION 641

SPECIAL COMMITTEE ON CONCRETE TIES

32—SYSTEMS ENGINEERING 641

Address—Application of Mini-Computers to Railroad Engineering Problems (Illustrated)

SPEAKERS

J. J. DiPaola, Field Service Department, General Railway Signal Company—In Hump Yard Operations

H. L. Chamberlain, Engineer of Structures, Missouri Pacific Railroad—Interface With Big Computers

J. H. Franks, Detector Car Operator, Atchison, Topeka & Santa Fe Railway—In Detector Cars

Installation of Officers

Adjournment

Nominating Committee, 1973 Election

Past Presidents

T. B. Hutcheson, *Chairman*
Assistant Vice President, Engineering & Maintenance of Way, Seaboard Coast Line Railroad

H. E. Wilson
Retired Assistant Chief Engineer System, Atchison, Topeka & Santa Fe Railway

H. M. Williamson
Chief Engineer System, Southern Pacific Transportation Co.

E. Q. Johnson
Assistant General Manager Maintenance, Chessie System

A. L. Sams
Vice President & Chief Engineer, Illinois Central Gulf Railroad

Elected Members

J. J. Dwyer (East)
Engineer Environmental Control, Chessie System

A. C. Parker (South)
Chief Engineer Maintenance of Way, Louisville & Nashville Railroad

R. E. Haacke
District Engineer, Union Pacific Railroad

M. S. Wakely
Chief Engineer, British Columbia Railway

C. L. Gatton
Assistant Chief Engineer—Staff, Louisville & Nashville Railroad

Committee of Tellers, 1973 Election

The following committee was appointed to canvass the ballots for officers and directors and for Members of the Nominating Committee, the count being made on March 20, 1973.

N. E. Whitney, Jr., *Chairman*
R. E. Ahlf
R. P. Ainslie
L. R. Beattie
L. E. Brault
S. W. Brunner
J. Budzileni
G. J. Chamraz
M. C. Christensen
R. Dirvonis
A. J. Dolby
R. A. Dugan
I. M. Hawver
E. H. Hofmann
R. E. Kuston
T. Lassen
G. W. Mahn
D. J. Moody
L. L. Rekuch
R. Rotter
A. J. Schavet
W. Stanczyk
W. S. Tuinstra

Successful Candidates in 1973 Election

For President

D. V. Sartore, Chief Engineer—Design, Burlington Northern, Inc., St. Paul, Minn.

For Senior Vice President*

R. F. Bush, Chief Engineer, Erie Lackawanna Railway, Cleveland Ohio

For Junior Vice President

J. T. Ward, Senior Assistant Chief Engineer, Seaboard Coast Line Railroad, Jacksonville, Fla.

For Directors

East:

J. T. Collinson, General Manager–Chief Engineer, Chessie System, Cleveland, Ohio

South:

R. W. Pember, Chief Engineer, Design & Construction, Louisville & Nashville Railroad, Louisville, Ky.

West:

W. E. Fuhr, Assistant Chief Engineer—Maintenance, Chicago, Milwaukee, St. Paul & Pacific Railroad, Chicago

B. E. Pearson, Chief Engineer, Soo Line Railroad, Minneapolis, Minn.

For Members of 1973 Nominating Committee

East:

B. J. Johnson, Regional Assistant Chief Engineer, Chessie System, Cincinnati, Ohio

South:

D. S. Bechly, Assistant Chief Engineer—Structures, Illinois Central Gulf Railroad, Chicago

West:

J. R. Williams, Engineer of Bridges, Chicago, Rock Island & Pacific Railroad, Chicago

Canada:

P. C. Fuller, Assistant Regional Engineer, Canadian Pacific Limited, Toronto, Ont.

At Large:

J. I. Adams, Assistant Vice President-Engineering, Louisville & Nashville Railroad, Louisville, Ky.

* Under the provisions of the Constitution, R. F. Bush advances automatically from Junior Vice President to Senior Vice President.

PRESIDENT'S ADDRESS

Address by President R. M. Brown*

At this point in the program it is traditional for me as President of the Association to review the activities of the past year and to identify some of the problems—which I would prefer to classify as "challenges"—that we are faced with in our area of expertise within the railroad industry. Also, to advise what courses of action are being considered or taken to overcome these problems or to meet these challenges.

In reviewing the activities over the year, I am pleased to report that our Association has done well from a financial standpoint. This is attributable to a great extent upon the fine response from the supply industry to our extended efforts to increase our revenue from advertising in the AREA Bulletins. From a membership standpoint, we have also done exceptionally well, not only in perpetuating a high level of membership from the railroad engineering fraternity, but also an encouraging increase in the number of members representing federal and state agencies, consulting engineers, and engineers representing railroad-related industries. This broad spectrum of membership activity and interest will help to ensure that our Association will continue to contribute to the future well-being of the railroad industry with the same degree of accomplishment that has been realized over the past 74 years. Further details on our membership and financial situation will be covered by the reports to be given by our most capable executive manager, Earl Hodgkins, and our punctilious treasurer, A. B. Hillman.

Probably the most inspiring thing that has happened within the Association this year was the eighth regional meeting held in Atlanta last fall. The meeting was organized under the enthusiastic direction of R. A. Kelso, a member of our Board of Direction and chief engineer—line maintenance of the Southern Railway System. This meeting surpassed all previous ones from an attendance standpoint, and the program was very well organized, well presented, and very informative. The concept of the regional meetings was conceived in 1965 to bring the AREA to our members in all geographic segments of the country, many of whom do not have the opportunity to attend the annual convention or participate in other Association functions. The response on the part of the membership in supporting these regional meetings has far exceeded the highest expectations of the Board of Direction.

Our Association has continued its policy of cooperation with other professional engineering societies and transportation organizations. Last summer the AREA sponsored several features in cooperation with the American Society of Civil Engineers at its Transportation Engineering Conference held in Milwaukee, Wis. The arrangements for the AREA presentations were under the capable direction of B. J. Worley, vice president and chief engineer of the Chicago, Milwaukee, St. Paul & Pacific Railroad, and a member of the AREA Board of Direction.

Let us now proceed to the problems, or challenges, facing the industry and the Association, and what courses of action we are taking to overcome them.

During the past five years, the railroad industry as a whole has been going through a steady transition from railroad operating practices of the past to modern, high-speed, heavy-tonnage operations that has transformed the conventional freight train into one containing an increasing majority of cars that are 90 ft long, carrying

* Chief Engineer, Union Pacific Railroad.

loads in excess of 100 tons, travelling at speeds approaching 75 mph, and committed to operating schedules as rigid as passenger trains were in years past. This change in traffic conditions has had a corresponding effect upon the track and roadbed structure.

The larger cars with their higher centers of gravity and heavier wheel loads travelling at higher speeds are creating some major problems in track maintenance that clearly indicate the most urgent need to redesign and strengthen some of our basic track elements to adequately withstand the high-speed impact imposed upon them under these changing conditions. In rail failure statistics alone, we find in territories handling around 50 million tons of traffic per year with these heavier cars operating in the 70-mph range, that internal defects in the rail and joint bars will progress from the incipient stage to the point of rupture in less than half the time experienced eight years ago when we were operating at slower speeds with fewer of the heavier cars in our train consists. Some of our latest findings would even indicate that the head surface of new rail being initially work-hardened under these high-speed, heavy-wheel-load conditions are going to develop some problems that we never experienced before.

Similar difficulties are being experienced with most of the other track components including the roadbed itself, the ballast, the ties, the switches, the frogs, etc. Some of these problems have been identified and corrected, others have been identified and are under investigation; and in some instances we recognize that problems exist, but we don't yet have them identified or actively under investigation. As these materialize, however, the responsibility to come up with necessary solutions is going to fall squarely upon the shoulders of the various technical committees of the AREA.

To further compound our problems in the industry, we are now faced with environmental quality regulations being established under federal and state statutes. Many of the installations on railroads will not presently meet these newly established requirements covering air pollution, water pollution, noise limits, etc. The cost required to bring our railroad facilities into compliance with these regulations is going to run into the millions of dollars. It is most certainly a challenge to the related AREA technical committees to address themselves to these problems and to develop the most efficient and economical means of bringing our railroad facilities into compliance with these new regulations.

In 1969, the Board of Direction recognized the need to consolidate and streamline our technical committees to keep up with the changing conditions brought about by the transition to modern high-speed, heavy-tonnage operations, and to insure that we could meet the further expanding demands of the transportation market of the future. This study indicated the definite need to reorganize and consolidate some of our technical committees and to re-evaluate and change many of the subcommittee assignments. In many instances, it was found that in much of the committee work the harvest was truly plenteous, but the laborers were few. With some of these committees having as many as 70 members, most of the significant work on several of them was being accomplished by the committee chairmen, vice chairmen, subcommittee chairmen, and a few of the most dedicated members with the remaining numbers contributing but very little to the cause. In other instances, it was felt that some of the subcommittee assignments of long-standing existence should be superseded by new assignments that would better meet the fast changing conditions being created by environmental regulations and our present day operating practices. To further compound the problem, the attendance at some committee meetings dropped off sharply due to the reluctance upon the part of some railroads to finance the cost of so many of their members attending their numerous meetings. This was unquestionably brought about by the ever increasing cost of travel and the continued cost-revenue pressures being encountered within the industry.

In order to fully evaluate the situation and be in a better position to determine what courses of action to take, the Board of Direction held a meeting last fall with all committee chairmen and vice chairmen to jointly discuss our problems, and to review the committee assignments, committee personnel, committee accomplishments, and committee activities.

Since that time, the Board of Direction has elected to implement some of the changes that have been under study and discussion for the past four years. Each of these issues has required a lot of soul-searching upon the part of every member of the board, and several of them involved considerable gnashing of teeth and rending of garments in the Board meetings before deciding which course of action to take. One Board member lost his front tooth at the Saturday Board meeting, but fortunately this was the result of his encounter with a hard roll at lunch and not the result of his exercising his democratic right to fight for what he thought was right.

I am fully convinced that the plans being implemented and others under consideration by the Board of Direction will make it possible for the Association to accomplish our professional responsibilities more expeditiously and more efficiently. By so doing, we will not only insure the continued active support of individual railroads and the industry as a whole to finance our membership activities, but we will also ensure our continued significant contribution to the advancement of the engineering profession and the railroad industry.

Before closing, I want to express my appreciation to Earl Hodgkins and his staff for their wonderful cooperation and assistance during this past year. Bruce Miller and his Convention Operating Committee also deserve a great deal of recognition for the efforts they put forth in arranging the countless details of these conventions.

I also want to extend a warm welcome to the ladies attending the convention and a special word of thanks to my wife, Elise, and to Ruth Hodgkins and the other women who assisted in arranging the ladies program. Even when I was going to college anyone was considered a fool who went to work in the engineering department of a railroad due to the migratory nature of the work, and any girl that married such a fool had to be of special caliber. In looking back over the many close friends and associates I have had in the railroad engineering profession, however, it would lead me to believe that life has a way of evening things up—for every woman who makes a fool out of some man there's a railroad man's wife who makes a man out of some fool.

ANNUAL LUNCHEON ADDRESS

Annual Luncheon Address

Can We Still Control Our Destiny?

By J. C. KENEFICK
President
Union Pacific Railroad

Being somewhat of an engineer myself, I speak with some diffidence to a group of professional engineers such as we have here, and it is also most difficult with so many distinguished presentations to be called upon to give the commercial, but here we go.

In all sincerity, an engineering background provides a valuable asset in directing anything as complex and technical as a modern railroad. I think that the Union Pacific has a reputation as a well-engineered railroad. It's a record that goes back all the way to our first chief engineer—perhaps one of the most famous railroad engineers in history—General Dodge. Although as a matter of fact he technically was not the first chief engineer, he succeeded a man who lasted only a few months after he quarreled with the president, but anyhow Dodge went on to lay out the route for the first transcontinental railroad and earned himself a place in the history books. I do think that he was a consummate engineer. His route across the wilderness is the same route we follow today. He said his success was due to three things: "brains, push," and a rather curious word, "combinations", but by combinations he meant combinations of people, alliances, the art of political maneuvering which was so necessary to put the project across.

In other words, Dodge was a realist. He knew better than to argue too strenuously with the boss, but he knew also how to achieve his goal within the political framework in which he had to operate. He could, in a sense, control his destiny, and that brings you around to the title which is "Can we control our destiny?", or have the technical and regulatory boundaries of our existence moved in too close?

Can we continue to push up productivity through technological advances? Can we make the huge investments needed to meet new regulatory challenges? Can we shoulder the environmental responsibilities brought about by each new legislative session?

As engineers you may well say that's not your concern, that you deal with physical problems only. I don't think many of you would accept that answer and certainly I wouldn't.

Dodge would have found a way and we must too.

How well we meet the challenges of productivity, regulation and environment will determine, I believe, how well we can continue to be able to control our own destiny.

Productivity, of course, to the railroad industry means an increased return on an increasing investment. Operating expenses for the industry have increased 27 percent in the last six years. The average railroad employ is now being paid more than $12,000 a year. It doesn't take much thought to see that productivity simply has to run fast to keep up with it.

How do we increase productivity to meet this challenge? How do you move more freight with the same number of people, to increase the work output of every piece of equipment you own?

One of the truisms that's going around the railroad industry these days is that we have reached the end of the road on productivity increases that can be realized from technological advances. We've had the diesel locomotive to play with for 20 years. Computers have already made their biggest contribution and so on.

I don't happen to buy that. We've only scratched the surface with computers. They have significantly improved train and car performance. Now we are turning them loose on terminals. The newest generation of diesels is giving us significantly improved operating results. Beyond that there seems to be a real promise of productivity gains in selective electrification. Electrification costs are not as high as they might seem—particularly when measured against regular capital improvement budgets. Locomotives of some sort will have to be purchased and electric locomotives have twice the life expectancy of diesels. They cost less. Maintenance costs are far less and the potential for high-speed, long-train opration is much greater. At least this is what our research indicates.

Don't misunderstand. I'm not coming out in favor of electrifying the entire American railroad system. The application would most certainly have to be restricted to limited high density operations. But I *am* saying that there are still many areas where significant productivity gains can be made through technological advances.

Those people who say we are nearing the end of the technological road remind me of the U. S. Patent Service who suggested in 1843 the time was near when no further mechanical improvements could be made.

Another broad area I would like to mention is that of the challenge of regulation. Regulations is certainly nothing new to our industry. It has been with us in varying degrees since 1887.

Today, increased regulation is laying a heavier load on you as engineers. Look at the federal track standards; of course, I am sure you have. By fall, you will have to meet them, and we all know about the requirement that establishes certain standards within certain speeds. The obvious result, I am afraid, is that after October 1 there will be a lot of slower moving trains, and this is certainly something we can ill afford in today's competitive situation. The trucks on those nice interstates are going to be moving at 60 mph or better.

However, I don't think it's entirely fair to look at the new track standards from a completely negative viewpoint. Bob Brown made an interesting point in an article he wrote for one of the railroad trade magazines. He pointed out the new track standards are really no more demanding than the main-line standards kept by major railroads 25 years ago when we were operating heavyweight steam locomotives and high-speed passenger trains.

Today, the diesel and discontinuance of passenger trains in many areas has done a disservice to the industry, I think, by allowing us to relax our standards. Now we will have to pay the price, one way or another—through slower operations or more investment.

The diesel freight trains that allowed us to relax those standards at one time were 50- or 60-car trains of 50-ton cars moving 50 mph, and now we are moving 100- to 200-car trains of 100-ton cars at speeds of 70 mph. The new track standards simply reflect the kind of physical plant required to move this traffic.

We have to have this kind of physical plant if we intend to stay competitive, if we intend to improve productivity.

Now the third area in which the regulators have found fertile grounds is environment. Here too, you engineers have a challenge to meet.

In January the Union Pacific took part in the final sad chapter of the story of the SST—the supersonic transport. We moved the mockup which cost about a billion dollars for the project on the first leg of a trip from Seattle down to Florida where it's going to be some kind of amusement. A lot of things killed that SST. Not the least of these were the warnings of ecological disaster promoted by a small but articulate group of environmentalists. Little notice has been paid to more recent studies which seem to be re-evaluating some of the earlier forecasts. Now that it is too late, it seems that the SST might not have created the horrendous problems its opponents predicted.

I think there is a lesson to be learned in this. We must work for a sane, rational approach to the very real problems presented by the need to protect our environment.

We are a long way past the time when any of us could afford to ignore environmental considerations in the plans that we make. The problems of air and water pollution exist and it is up to us to do something about them.

I think the railroad industry has a good story to tell. The public is little aware of how greatly the diesel locomotive has contributed to clean air. On those occasions when we get out our one steam locomotive in Cheyenne and the whole citizenry of Wyoming get all tingly when the whistle blows, they can see a lot of black smoke at the same time.

Now we *can* tell our story better, and we *can* remind the public that every ton of freight hauled by rail reduces the amount of air pollution by 50 percent or more compared to highway transportation.

In terms of land use we can remind the public that railroads and trucks haul about the same amount of intercity traffic now, yet the existing federal aid highway system occupies about 13 times as much land as the existing Class I railroads or approximately 32 million acres compared to 2.5 million acres. It has been estimated that the present United States rail system has sufficient capacity to handle three times the traffic load it is now carrying, and with relatively minor changes in operations and signalling, many railroads could increase their capacity by seven times the present rate.

In contrast, we are currently building about 11,000 miles of new federal aid highways every year, or stated another way, we are paving over about 22,000 acres per year, and if the AAR projection of a 46 percent increase in freight traffic through 1980 is correct, this rate of construction will not be sufficient to handle the motor carrier's expected share of the increase.

Also, it is known that the total traffic-carrying capacity of highways is decreased significantly by the admixture of trucks with passenger cars. Current figures in use for multilane highways indicate that each truck reduces the passenger car carrying capacity of the highway by two on level terrain, by four on rolling terrain, and by eight on mountainous terrain.

In the area of noise pollution, we are still in the stage of trying to develop enough data to establish standards and make comparisons. But information available thus far indicates railroads, again, have a distinct advantage over vehicular traffic. That does not diminish a situation which translates into a problem for all of you as well as our mechanical engineers. As the urban areas press in more closely to our facilities and as residents become more aware of noise pollution, we are being confronted with difficulties similar to the airlines' in urban areas around airports. Some of this may be solved mechanically, but it will always have to be considered in your sphere.

Now it's certainly a fair question for you to ask just what can be done to meet the challenges of productivity, regulation, and environment. There is no sweeping answer, but there are some beginnings that we can make right now. You can begin to think in terms larger than textbook engineering. How will productivity be affected by the plans you make? What will be the environmental impact of the project? How can the work of the regulators be guided into rational and helpful lines?

We know some of the most critical decisions are not in our immediate control. They rest with Washington. For instance, if we are to meet the new track standards, some of our Member Roads are going to have to have aid along the lines contained in the Surface Transportation Act. While it was a deep disappointment that the bill failed to pass the last Congress, we cannot afford to relent now. Your help and the support of all your suppliers is needed now more than ever.

The survival of any living thing depends in a large part on its ability to meet changing conditions. This is a fundamental rule of nature. It is also becoming an increasingly fundamental rule of business and industry. The engineering forces of America's railroads have long been leaders in shaping their industry to the needs of the nation. Your challenge today is greater than it ever has been if we are to control our destiny. None of you can afford to stay neutral in this time, or wait for so-called "management" to assign the many problems. Remember that the success of an engineer is as General Dodge said: "Brains, push, and combinations."

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Impressions of European Railway Practices

74–643–1

by J. G. GERMAN
Assistant Vice President—Engineering
Missouri Pacific Lines

In October 1972, I toured Western Europe and visited with top track and locomotive men on the Federal Railways of Germany, Austria, Switzerland, France and England. In the process I rode 15 passenger trains and 3 locomotives, visited several shops and manufacturing plants, visited the Munich Technical University and the British Rail Research Center at Derby.

Exhibit A compares United States Class I roads to these European roads.

Operating Practices

When an American reads technical papers on European Railroads, he automatically thinks about miniature locomotives and cars and picturesque rights-of-way, and it is difficult to equate in his mind practices and standards of European railroads versus those on the North American continent. While it is true that many of their operating practices are different, they still have the basic problems that we do, except on a somewhat different scale. For example, they are gravely concerned about lateral track stability, line clearances and motive power performance.

It is obvious, due to densely populated areas, the high cost of gasoline, and insufficient roadways and parking areas for vehicles, why European railroads have long been passenger-train oriented.

Axle loadings for rolling stock are a maximum of 20–21.5 tons as compared to 32.75 tons for the U.S.A. Actually their light axle loadings stemmed more from close line clearances than as the result of restrictions on roadbed and bridge structures. (See Exhibit B).

Clearances

Most of these roads were plagued with a considerable amount of curvature, and due to the fact the countries were already well populated prior to the advent of railroads, they were hemmed in by buildings, bridges and natural terrain and were unable to lay out their roads for better clearances as we have done in the United States. Due to density of traffic they have many multiple-track main-line segments, and apparently they are reluctant to trade off some of these multiple tracks for better clearances. When one considers that there are in excess of 400 trains every 24 hours between Dusseldorf and Duisberg and more than 800 trains in 24 hours from Munich east, and in excess of 300 trains in 24 hours through Charing Cross, with many more examples to be found all over Western Europe, it is obvious that traffic density poses the most serious operating problem of all.

Classification Yards

I was unable to see any electronic classification yards; however, there are numerous small classification yards with a hump about 9 ft high and only 4 or 5 bowl tracks. In Germany and Austria some of the hump engines were large Mikado-type steam locomotives and in every instance, no matter what country, they seemed to be able to switch their cars quite rapidly, either over the small humps or in flat yards. It was rather frightening to see the men step between the equipment and make the couplings.

Note: Discussion open until October 15, 1973.

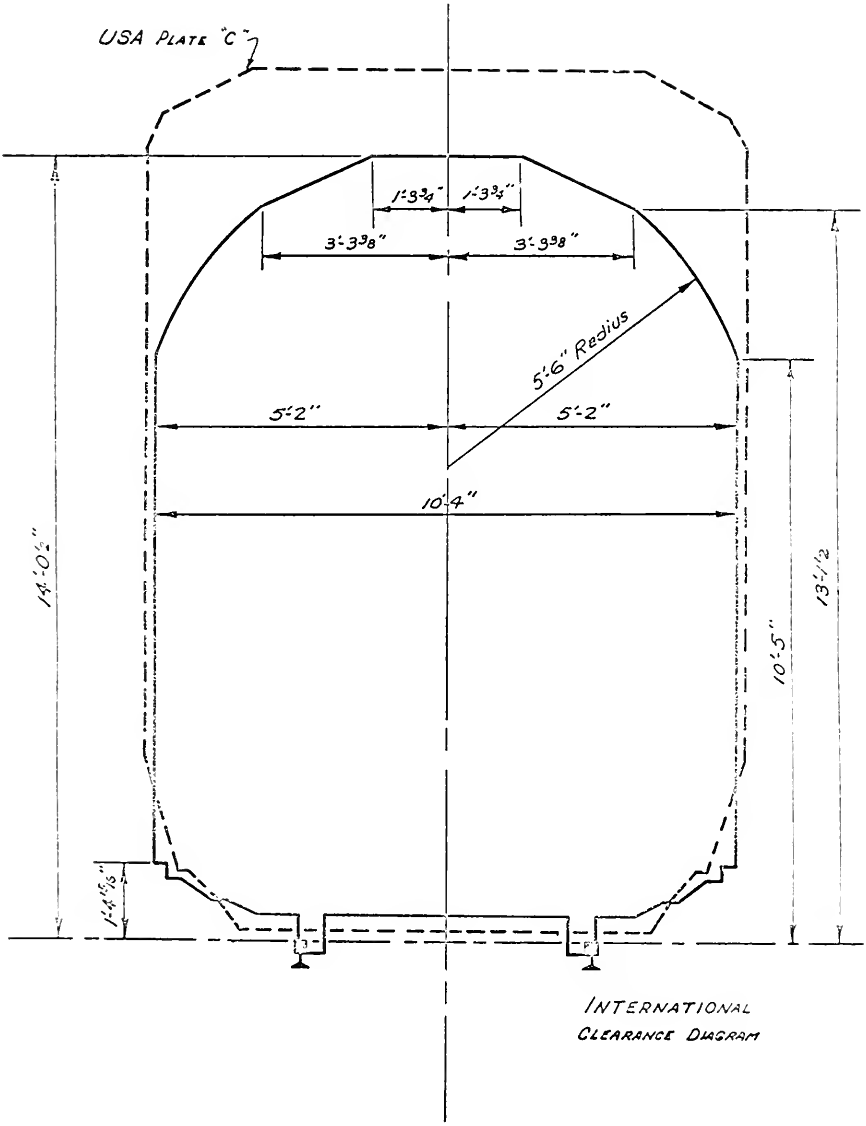
EXHIBIT A

COMPARISON OF U. S. CLASS I RAILROADS
to
WEST EUROPEAN FEDERAL RAILROADS

COUNTRY	U. S. A.	W. Germany D.B.	Austria O.B.B.	Swiss SFF	French SCNF	British B.R.
Population (1,000's)	203,185	61,682	7,420	6,527	50,775	46,254
Area, Sq./Mi. (1,000's)	2,615	96	32	16	211	50
People, Sq./Mi.	56	643	229	409	240	919
Route Miles	205,000	18,861	3,373	1,810	22,318	11,799
Track Miles	334,000	N/A	6,394	4,186	48,827	31,281
Locomotives						
Steam	13	1,895	350	-	412	
Diesel	26,899	4,031	335	103	4,266	4,176
Electric	252	2,261	497	851	2,207	323
TOTAL	27,164	8,187	1,182	954	6,885	4,499
Passenger Cars						
Self-Prop.	N/A	1,650	723	191	3,137	10,981
Trailers	N/A	18,007	3,780	3,421	11,500	7,715
TOTAL	6,842	19,657	4,503	3,612	14,637	18,696
Freight Cars	1,762,135	274,028	34,521	25,707	302,600	364,884
Axle Load, Ton	32.75	20.00	20.00	20.00	23.00	22.50
Rail, #/Yd.	119/136	110/130	86/122	108.7	109/121	110
Tie Space, In.	19½"w	27½"c	25½"c	25½"c	24½"c	30"c
Per Mile	3,250	2,300	2,480	2,480	2,586	2,112
Tie Length	8'6"w	8'6"c	7'10½"c	8'0½"c	7'7"c	8'3"c
Employees	544,369	386,265	71,572	40,673	300,300	276,063

N/A Not Available
W - Wood
C Concrete

EXHIBIT B


USA PLATE "C"
1'-3¾"
1'-3¾"
3'-3⅜"
3'-3⅜"
5'-6" Radius
5'-2"
5'-2"
10'-4"
14'-0½"
13'-1½
10'-5"
1'-4 15/16"
INTERNATIONAL
CLEARANCE DIAGRAM

Couplers

On the continent, the hook-and-screw type coupler is standard on all equipment. There are plans under way to have this changed out by 1986; however, the problem of interchanging equipment and use of adapter cars becomes very acute.

Flat Switching

In Switzerland and also in England, I witnessed flat switching of passenger equipment where they cut the equipment off on the fly. The Swiss at Berne were especially adept at this and I was amazed at the speeds they used, as the cars had a considerable distance to go. The rider used air brake or hand brake as necessary to control the car from 20 mph to a low-speed coupling.

Freight Trains

Freight trains are generally short and on the continent they are usually limited to 120 axles or 2,400 tons gross. Usually freight trains range from 15 to 40 cars. In several of the countries there was no caboose and oftentimes the only man on the train was the engineer.

Piggyback in Reverse

When driving through Munich, I was astonished to meet a tractor-truck trailing a low boy which contained a hopper car of coal. When I asked the reason for this move, I was informed that many of the customers do not have direct rail access; therefore. the German Federal Railroad served them in this manner.

Track

Track standards and methods were quite uniform in the five countries visited. (See Exhibit C) This is no doubt due to the fact that they all interchange lightweight equipment and, from a geographical standpoint, are so close to each other that exchange of ideas and methods is easily accomplished. Also, it appears that there is considerable cooperation through the UIC and ORE associations.

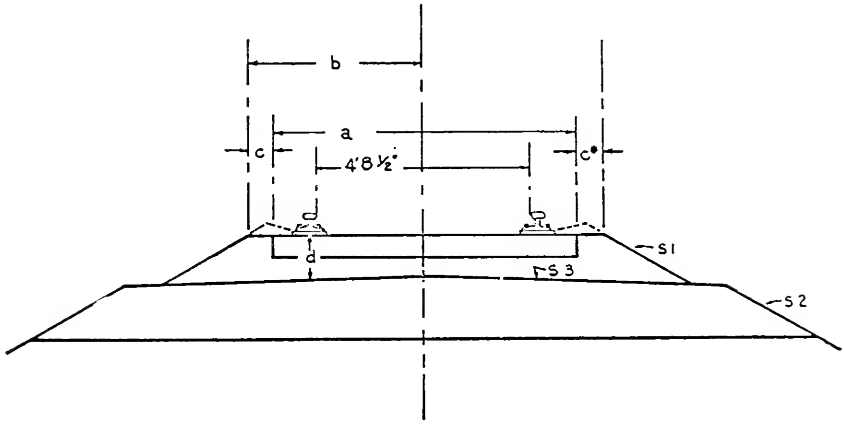
Ties

While there were basically three types of ties, wood, metal and concrete, there was certainly a wide diversity of opinion about ties in regard to size, shape and fasteners. Wood ties are costly on the continent due to the scarcity of timber; however, the wood ties that I saw were of good grain and relatively fair to excellent condition. In several countries it was the practice to band the ends of the ties to keep them from splitting or checking and all wood ties that I saw were treated. In each of the countries they advised that the wooden ties, complete with fasteners (similar to those used on concrete ties) were more expensive from a material standpoint than concrete ties. Furthermore, in certain areas where they had high moisture content, the life of the wooden tie was quite short, and when compared on the basis of total life they advised that wooden ties cost approximately three times that of concrete ties.

I noted metal ties in use in Switzerland and also to a limited extent in France. These appeared to be metal plates that had been hot pressed to the shape desired. While the Swiss are still buying a limited number of metal ties each year, I got the indication that they were not as easy to keep stable in the roadbed due to their shape.

EXHIBIT C

TYPICAL CROSS SECTION IN WELDED RAIL TERRITORY



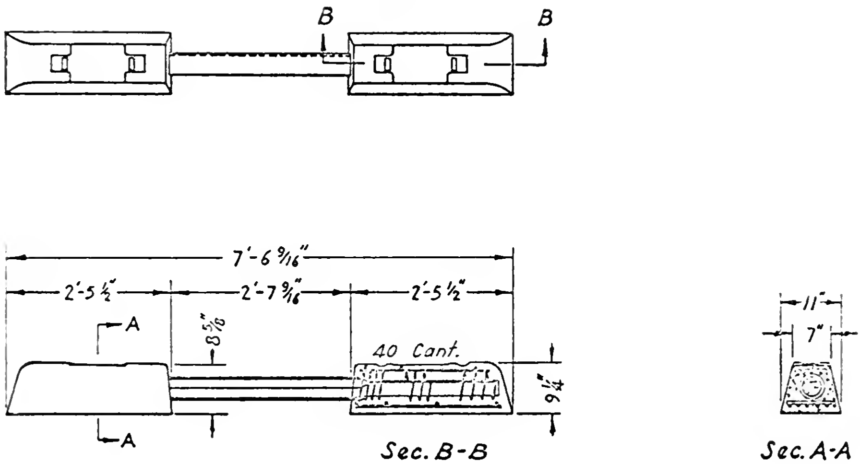
	a	b	c	c*	d	S1	S2	S3
MoPac	8'6"w	5'3"	12"	12"	12-14"	3:1	2:1	20:1
German Fed.	8'6"c	5'7"	16"	24"	18"	1.25:1	1.5:1	20:1
Austrian Fed.	7'10½"c	5'7"	18"	18"	18"	1.25:1	1.5:1	25:1
Swiss Fed.	8'0½"c	5'0¼"	12"	18"	12"	1.25:1	1.5:1	20:1
French Fed.	7'7"c	4'9½"	12"	12"	12"	1.25:1	1.5:1	20:1
British Rail	8'3"c	5'1½"	12"	18"	18"	1.25:1	1.5:1	20:1

w = wood ties

c = concrete ties

* = On outside of Curves 4° or Over

EXHIBIT D



French Tie

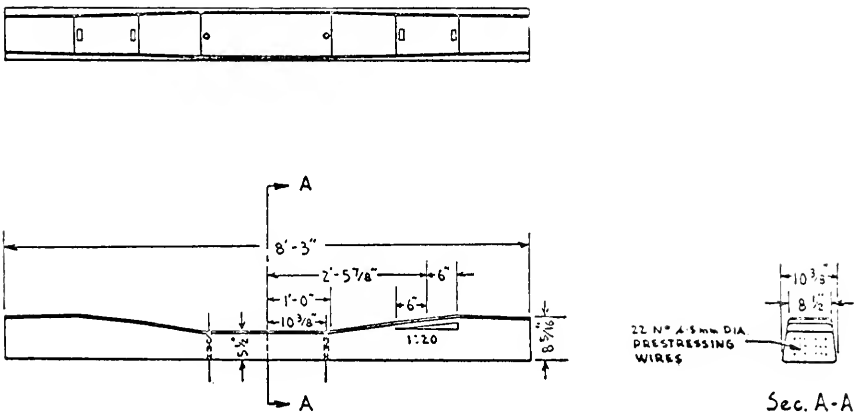
Concrete ties were widely favored in all five countries; however, there is still some argument among the different roads as to the exact shape and method of reinforcing these ties.

The French tie consists of two concrete blocks with an angle iron for a spacer and admittedly was more difficult to keep in alignment. (See Exhibit D). Furthermore, in the event of a derailment it was alleged that type suffered more serious track damage due to the bending of the angle iron.

The British F27 tie (See Exhibit E) contains 22 strands of 4.5-mm diameter prestressed wires. The mid-section is only 5½ inches thick as opposed to the ends which are 8 5/16 inches thick. The advantage of this sway-back construction is that the ballast section between the rails will protect the tie to a certain extent from minor derailments. The disadvantage of this particular tie is that the strands of wire prevent using the optimum aggregate size for the best bonding of the concrete work.

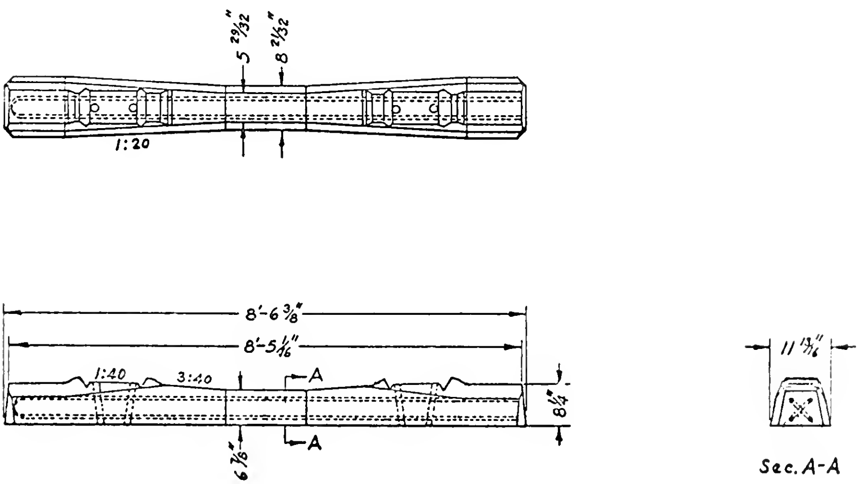
The German B70 tie (See Exhibit F) is necked down in the center to a depth of 6⅞ inches as opposed to 8¼ inches on the ends. Furthermore, the width of the tie in the center is considerably reduced. In addition to the advantage of the more shallow depth being protected by an overburden of the ballast in the event of derailment, it is claimed that the hour-glass shape of the tie, as shown in the top view, increases lateral stability when the crib as well as the shoulder is compacted after tamping. This particular tie is reinforced with two long U-shaped rods. Examples that I saw of tests made at the Munich University indicated that this tie seemed to have more resistance to fracture from being high centered or subjected to derailment. The new German B70 tie uses plastic inserts for the fasteners in lieu of the wooden inserts which rotted out of the B58 tie. While at Linz I visited a tie manu-

EXHIBIT E



British Tie F 27

EXHIBIT F



German Tie
B 70W-60

EXHIBIT G

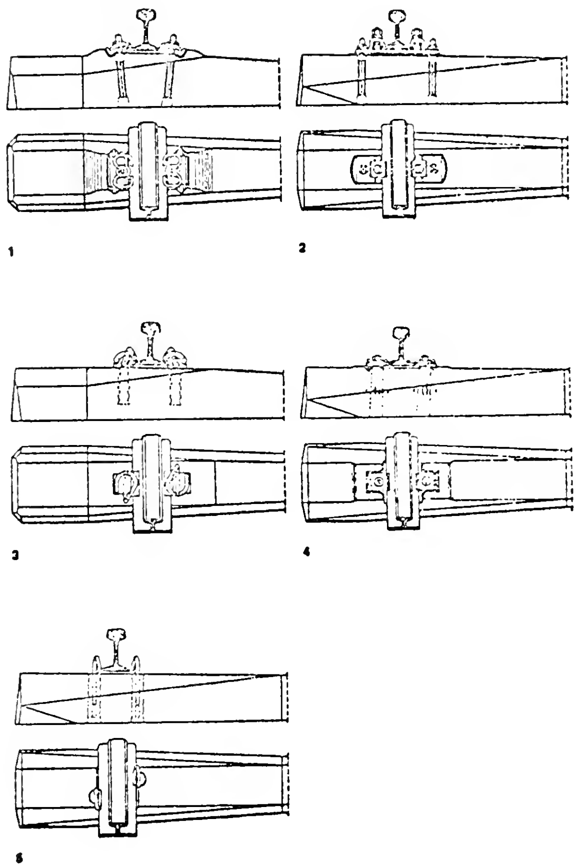
1 "HM" Rail Fastening for Main Lines (Designated by the Deutsche Bundesbahn as "W" Fastening)

2 Rib-Plate Fastening for Main Lines

3 Pandrol Fastening for Main Lines

4 "RN" Rail Fastening for Main Lines

5 Elastic Spike Fastening for Sidings



facturing plant operated by Dyckerhoff & Widmann under the trade name of Dywidag. At the time of my visit they were producing 500 prestressed concrete sleepers daily to the German B70 specifications.

Adjacent to the office they had a display that showed the history of the concrete tie in its various stages of development, also the history and development of various types of rail fasteners. (See Exhibit G)

Fasteners

The "HM" fasteners, known on the German Railways as the "W" and the Pandrol fastener, appeared to be the most popular; however, one could see many styles of fasteners on the different classes of track but seldom did I see loose fasteners or ties cracking under the seat of the tie plate. Periodically one did see a small crew of men checking and tightening rail fasteners.

Rail

As shown in Exhibit A, the weight of main line rail varied from 86 to 130 lb per yard, with most of the rail being in the neighborhood of 110-lb sections. All countries were installing continuous welded rail as rapidly as possible. They weld short sections of rail in lengths up to 1,100 to 1,200 ft long and call these strings long welded rail (LWR). Some countries permit the steel mills to flash butt weld short remnants of stick rail to make lengths up to 60 ft, which are distributed to the railroad companies' flash butt welding plants and incorporated into LWR. After the LWR sections are placed in the field, then the angle bars are removed and a thermite welding process is used to make what they call continuous welded rail (CWR) sections up to 25 to 30 miles long. It is common practice to weld through the switches and even the switch point is welded in place. The result is an extremely smooth riding railroad.

Several people stated that while the incidence of failures of thermite welds was rather high due to infant mortality, over a period of five or six years it was only about twice as great as that of flash butt welds, and that the failure rates of both of these practices were so low as compared to the bolt hole fractures, etc., plus pull-aparts on joints, that they were not very greatly concerned about using thermite welds in the field. When LWR rail is placed in the field, there is a section of rail of the same weight, approximately 1 ft long, placed adjacent to this string. This test section has a hole drilled lengthwise through the head to receive a pyrometer. The pyrometer reading is thus internal to the head and not subjected to the effects of moisture and wind wipe. Consequently, the parameters that they use for stretching rail are based upon a somewhat different scale than we use over here, but generally speaking they use the same practice of stretching rail as U. S. roads; namely, propane torches or hydraulic jacks. They also use vibrators in connection with rail stretching to insure an even distribution of tension. They do not disturb the track section in continuous welded rail territory when the ambient temperature exceeds 90 F.

Ballast

The ballast on main-line routes appeared comparable to AREA "B" and "C" in sizes and fractures. Most of the ballast on the continent appeared to be of the granite type while most on the British Rail was the limestone type. Ballast section under the base of the rail ranges from 12 to 18 inches with the 18-inch depth being the most widely favored for heavy-duty lines.

I was surprised to see so many of the lines having excess ballast from the outside of the rail over the ends of the ties to the height of the top of the rail. I determined that this was placed there deliberately and that their ballast regulators are so designed to handle it in this fashion for two reasons. The first reason is that this supercharging of ballast over the ends of the tie gives the track more lateral stability in welded rail territory. The second reason is that whenever they wish to make a light surfacing lift of the track, they have ballast immediately available that can be placed in the cribs and compacted to quickly insure the lateral stability of the track.

In all countries except Britain it was common practice to have contractors take care of the surfacing as well as renewal of ties and rail as opposed to American and British practices of doing the work in place with their own manpower.

Lateral Stability

All of the European track men were agreed that tamping would reduce lateral stability from 75 to 90% but that immediate compaction would restore some 60 to 70% of the loss and that by the time some 200,000 gross tons of traffic had passed over, the track would be within 95% of its original stability. Both the Munich Technical University and the Derby Research Laboratory have done considerable research work on the effect of tamping and compacting on lateral stability. The Munich Technical University has correlated soils lab work with field tests on the German Federal Railroad and seem to come up with about the same philosophy and figures as the British Railroad, which has a rather elaborate test section at Derby. At Derby they use this test section first to determine facts and figures in regard to lateral stability and secondly as a means of rating effectiveness of various tampers and compactors. We need to do this same type of work in America with our type of rail, fasteners, ties and ballast. The Derby setup impressed me as it was possible to use a full-size tamping machine or compactor and not have to use mathematical methods, etc., to relate laboratory practice to real life.

Near Misses Make Money

74–643–2

By L. R. BEATTIE
Assistant Engineer
Atchison, Topeka & Santa Fe Railway

The title "Near Misses Make Money" could be a misnomer. To those of you who believe it is a misnomer, I would say, perhaps you lose on every odd-ball load, but you make it up on the volume.

Seriously, 15 years ago, yes, even 10 years ago a high or wide load was an oddity. Today these loads are everyday loads. High-Wide-Long and Heavy.

Yesterday, we told the shipper to cut the load in half. If it were a tank, he did.

Today, the shipper is shipping excess-size loads that can't be cut in half.

Can we meet the challenge?

Some major manufacturers will pay a pretty penny to anyone that comes up with an idea that will let them carry heavier loads and still meet our specs on axle loading. The only idea I could think up was to float the load with helium. A 2-million-pound load would need quite a bag of helium.

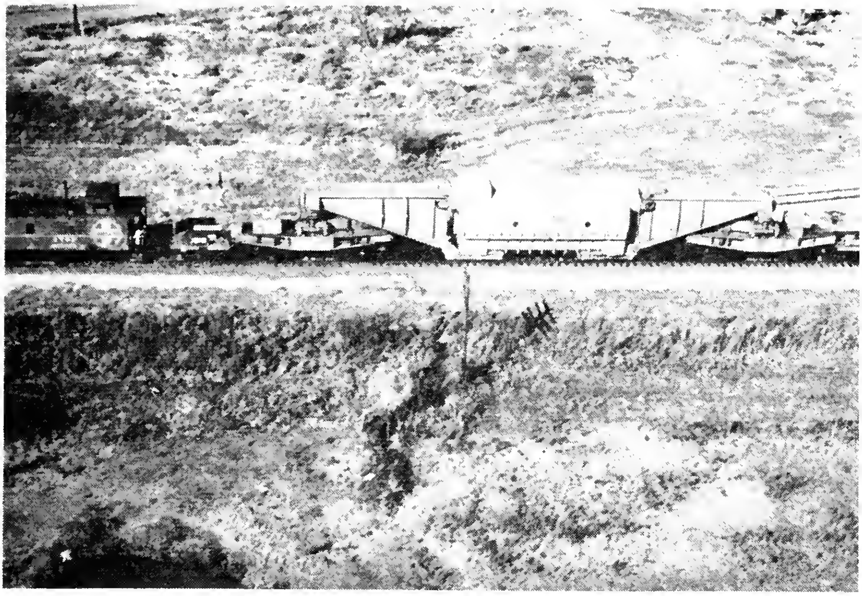
Also, these manufacturers are willing to contribute to the cost of upgrading certain tracks, if that is the best solution in delivering their product—and we should remember that once track has been upgraded for a wide-high-long and/or heavy load, this one load should generate more loads to the same destination.

These builders of high-wide-heavy loads—transformers, generators, reactor vessels, etc.—state that the sizes can only get longer, higher and wider; field welding is not the answer.

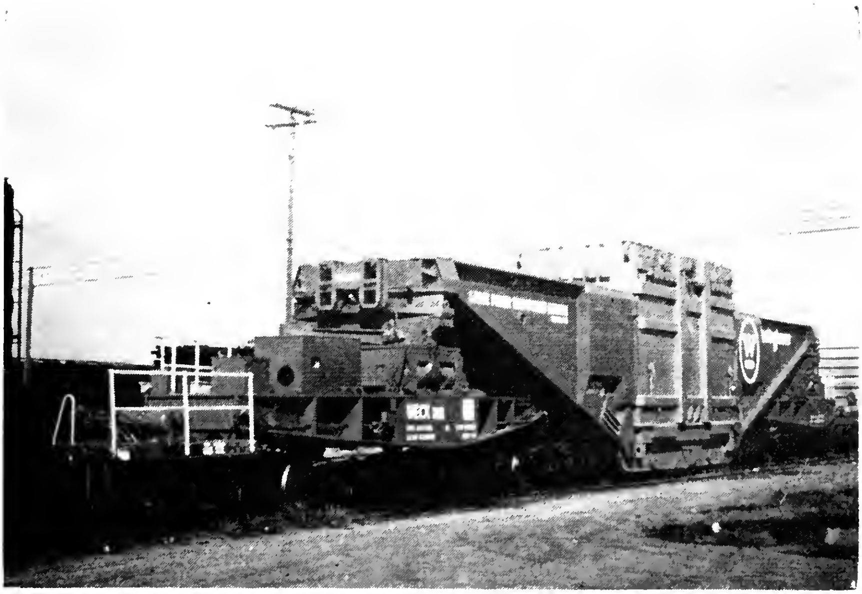
Better clearances is the answer. Whenever and wherever we have the chance, we should eliminate a clearance problem. We should be service oriented to make money—Near Misses *Should* Make Money!

(Mr. Beattie presented 80 slides to illustrate his talk, but for lack of space, only 18 are reproduced on the following pages.)

Note: Discussion open until October 15, 1973.

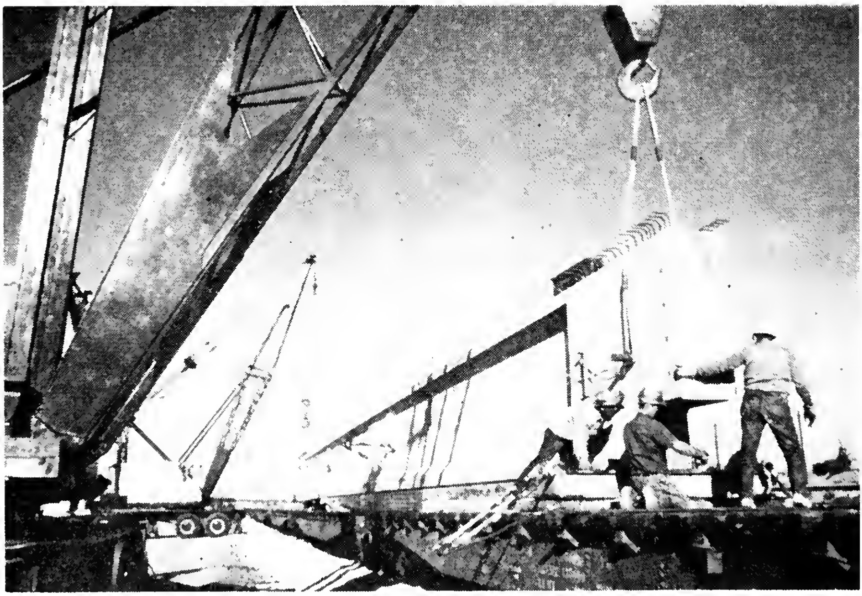


Westinghouse Generator, WECX 101, Santa Fe Series.

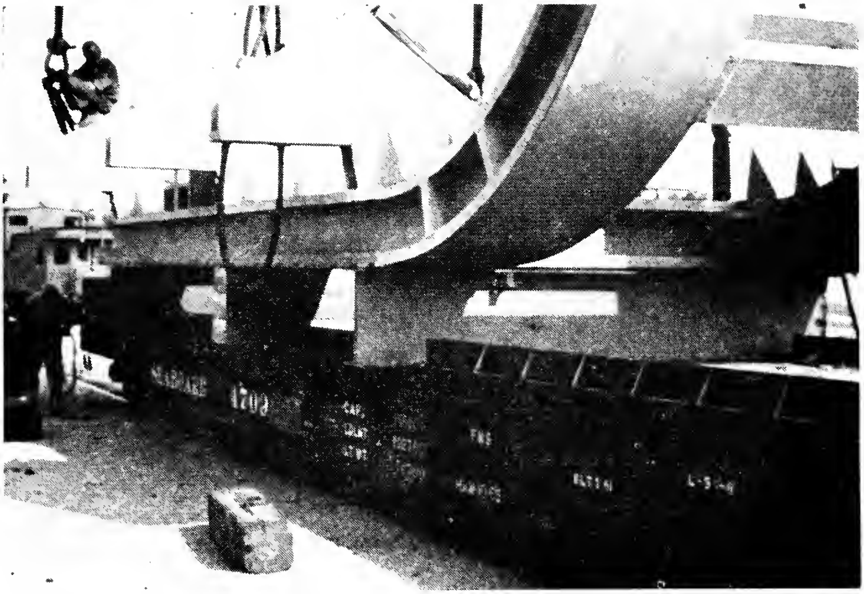


Westinghouse Generator, WECX 202, on the Union Pacific at Council Bluffs, Iowa.

Girders up to 100 ft. long riding on and braced directly to trucks.

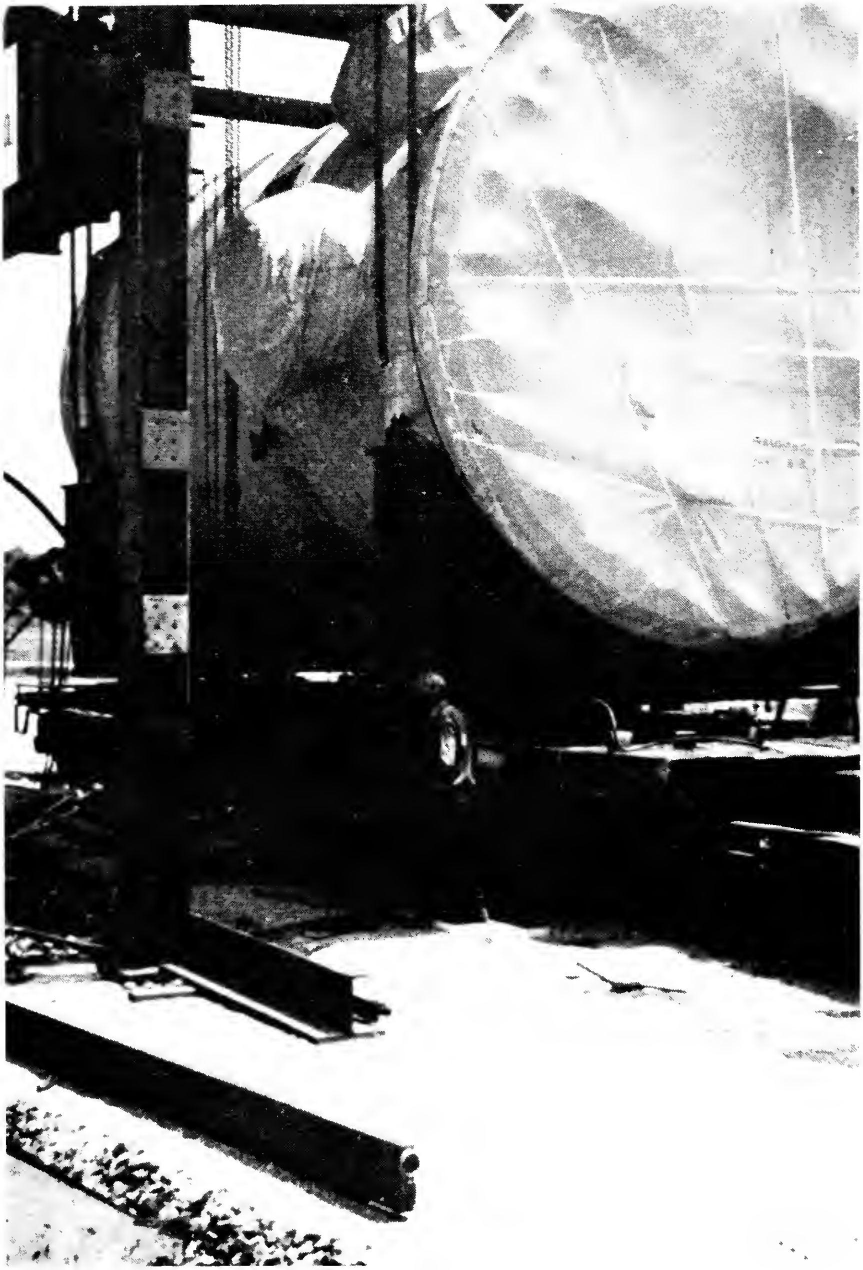


Prestressed concrete beams being loaded on two flat cars.

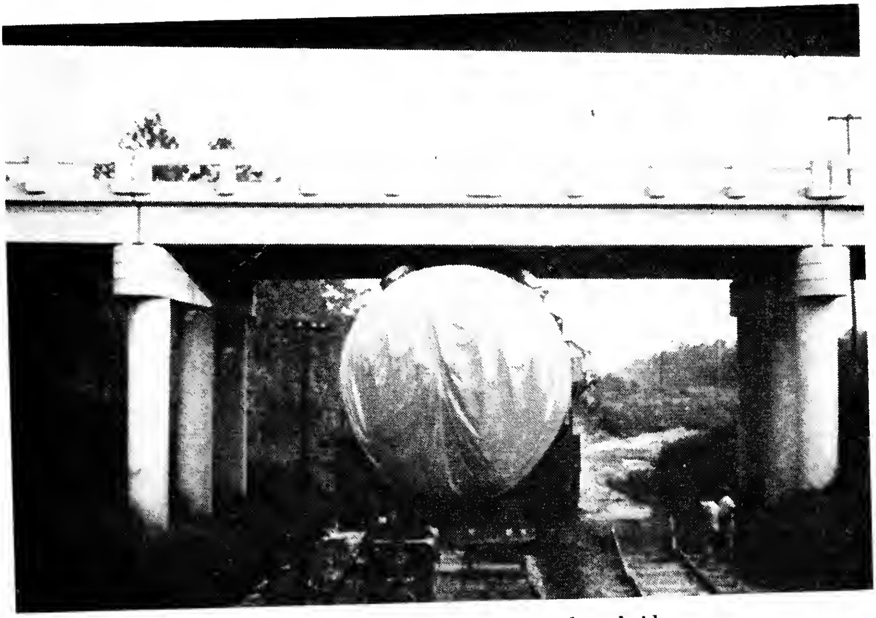


Skid for a reactor vessel.

Double haul for skids.

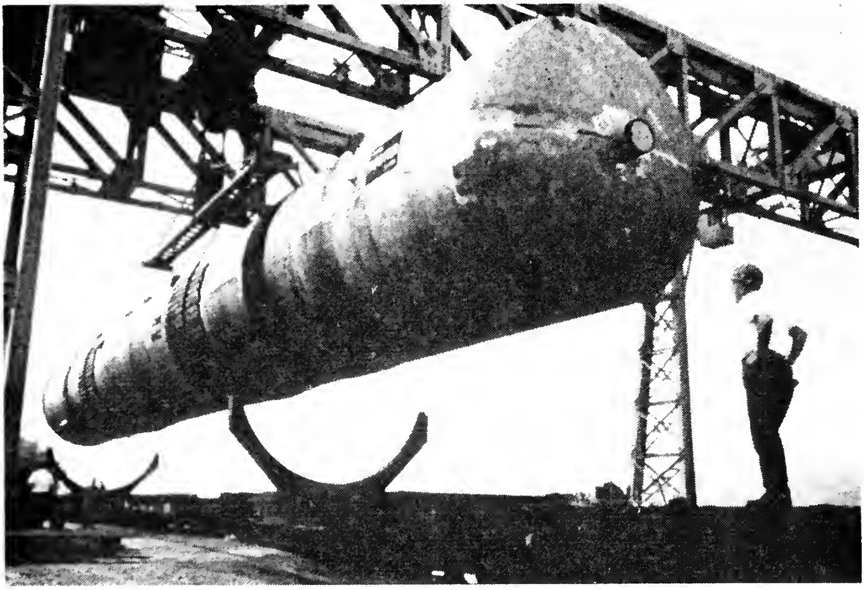


Loaded reactor vessel.

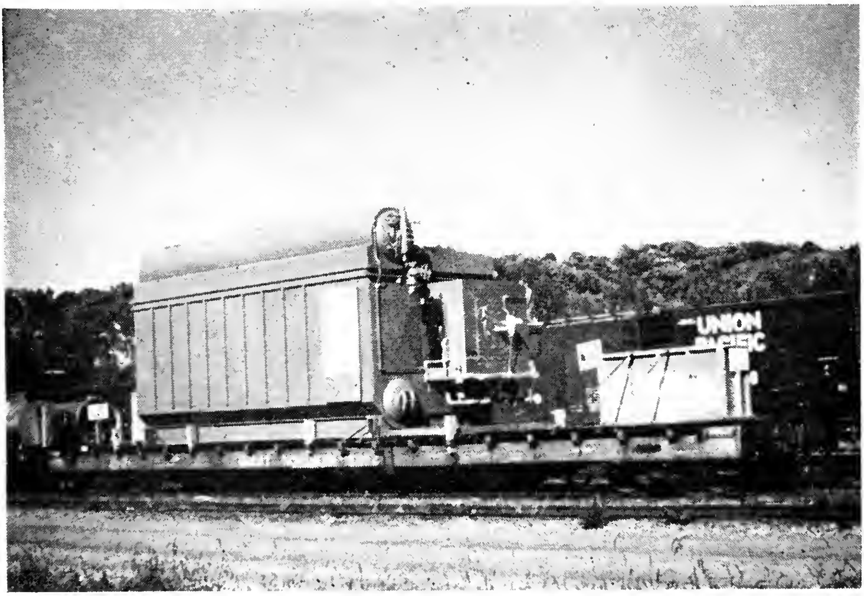


Track lowered to permit load to clear bridge.

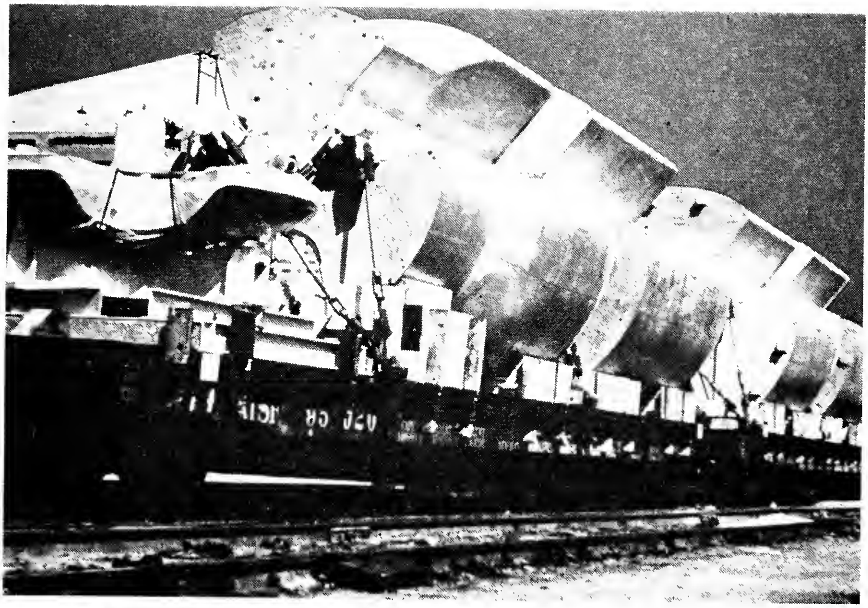
Container box for airplane wings.



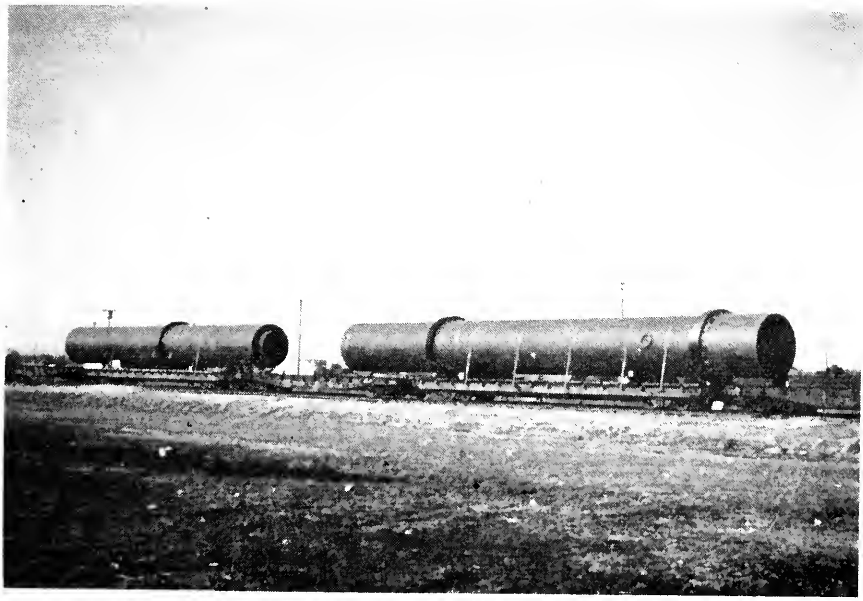
Pipe 130 ft. long, 150,000 lb, being loaded.



Transformer.

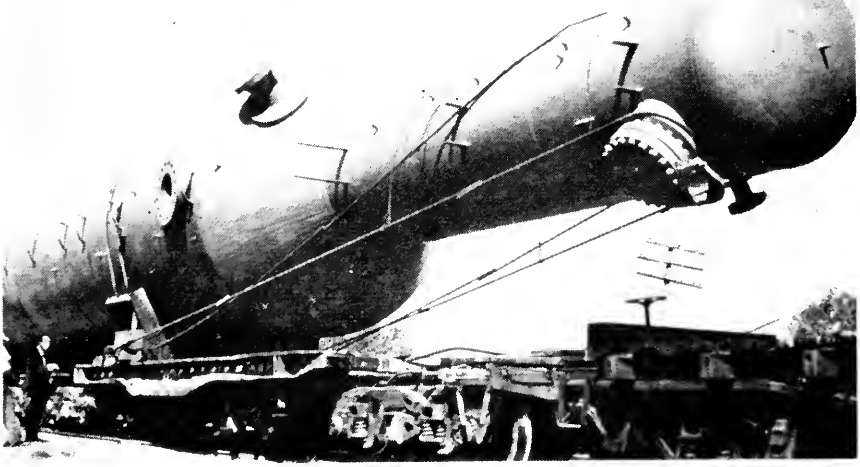


Lift bridge counterweights (concrete).

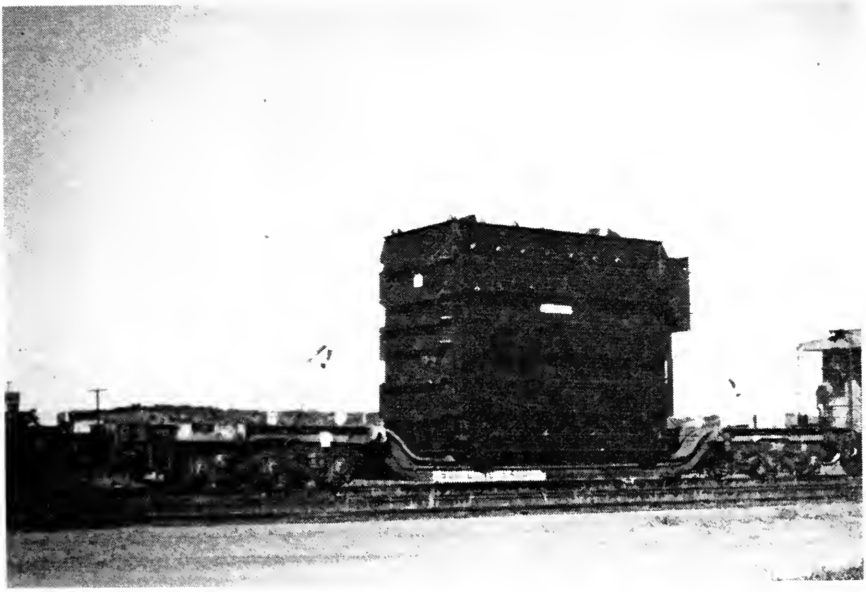


A single load, double end overhang.

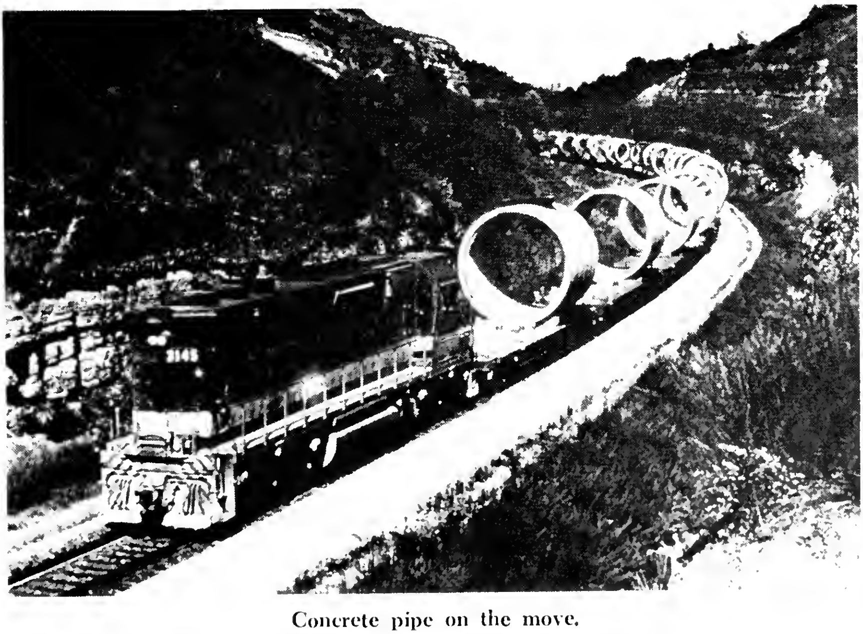
Pipe loads on 54-ft flat cars.



Steel vessel, weighing 385 tons, for natural gas processing moving from Houston, Tex., to California.



Depressed flat car.



Concrete pipe on the move.

16-ft concrete pipe in well car.

Railroad Problems on the Arkansas River Navigation Project

74–643–3

By H. L. CHAMBERLAIN
Engineer of Structures
Missouri Pacific Railroad

Forming one of the major tributaries of the Mississippi, the Arkansas River rises on the eastern slopes of the Rocky Mountains. Flowing in a generally southeast direction, it drains large areas of eastern Colorado, southern Kansas, northeastern Oklahoma, and central Arkansas.

In 1946, under the sponsorship of Senators McClellan of Arkansas and Kerr of Oklahoma, the United States Congress authorized a measure to carry out major improvements for navigation on the lower reaches of the river, and to provide a navigable channel from the Mississippi to Tulsa, Okla. Work was progressed as money was appropriated by the Congress.

From the Mississippi River, upstream past Pine Bluff, Ark., through Little Rock and Fort Smith, Ark., to the Port of Catoosa, Okla., some 436 river miles, a navigation channel of specified depth clearance, and location is provided for. Although intended primarily as an aid to navigation, the project provides some general benefits, such as a degree of flood control, through the required river control structures on the upper reaches.

The lower reaches of the river are tortuous and difficult for navigation. Consequently, river traffic is diverted through the new Arkansas Post Canal between Dam No. 1 and Lock No. 1 to the White River, a much shorter and easier route to and from the Mississippi.

The Arkansas has a very steep fall, the average gradient over the length of the navigation project being on the order of 1.2 ft per mile. The current is swift and carries an enormous burden of silt, sand and gravel. Maintenance of the channel to required depth and location is costly and in times of high water work on the river can be very difficult.

The total fall of approximately 500 ft through the length of the project required construction of 18 sets of locks and dams, plus various other river control structures.

In addition to construction of locks, dams and river control structures, no less than 17 major river crossings required removal, rebuilding or major modification. Of these, seven were structures carrying railroad traffic.

Starting upstream at Fort Smith, two railroad bridges were involved, one belonging to the Frisco and the other to Missouri Pacific. Joint operation was practical at this location and the older Missouri Pacific bridge was removed. The Frisco bridge was modified to provide a vertical lift drawspan over the channel to carry the operation of both railroads.

Downstream, at Little Rock, three railroad bridges were involved, two belonging to Missouri Pacific and the third to the Rock Island. No possibility of joint operation was available at this location. The Rock Island bridge and one Missouri Pacific bridge were provided with vertical lift drawspans and the other Missouri Pacific bridge was provided with a vertical lift of longer span.

Farther downstream at Rob Roy, near Pine Bluff, the bridge carrying the Cotton Belt over the river had a vertical lift span added.

Note: Discussion open until October 15, 1973.

Finally, at Benzal, Ark., just below Lock No. 1, the Missouri Pacific bridge over the White River is presently undergoing modification to provide vertical lift draw operation.

On all but two of these bridges the modifications consisted of replacing the swing drawspan with a vertical lift drawspan. The exceptions were the Rob Roy bridge where the swing span was locked shut and a vertical lift provided over the relocated channel, and the Missouri Pacific bridge where a longer lift span was provided.

Slide 4 shows the Frisco bridge at Fort Smith with its new vertical lift drawspan.

Slide 5 shows the Missouri Pacific's Baring Cross bridge at Little Rock during construction. Notice the arrangement of the shoofly track to carry traffic for this bridge as well as the Missouri Pacific's junction bridge about a half-mile further downstream. This bridge had a vertical lift span which was too short for channel requirements.

Slide 6—Looking downstream at the Little Rock reach. In the foreground is Missouri Pacific's Baring Cross bridge as completed and in service.

Slide 7—A view of the Little Rock reach, looking upstream. In the foreground is the Rock Island bridge during modification. Upstream, beyond the first highway bridge, is Missouri Pacific's junction bridge, also undergoing modification. The last bridge in this view is Missouri Pacific's Baring Cross bridge.

Slide 8—A view of Missouri Pacific's junction bridge as completed and in service.

Slide 9—Looking again upstream through the Little Rock reach. In the foreground is the Rock Island bridge as completed and in service. Next is the new Interstate Highway bridge almost completed. Next, Missouri Pacific's junction bridge completed. Fourth, the Main Street bridge at the start of modification. Although not shown here, the navigation channel has now been spanned with a rather lovely steel arch structure. Another highway bridge undergoing modification as a twin to the Main Street bridge and, finally, Missouri Pacific's Baring Cross bridge.

Slide 10—Here is the Cotton Belt bridge at Rob Roy prior to modification.

Slide 11—The Rob Roy bridge at start of construction showing the unusual shoofly arrangement. The swing span has been turned off about 10 degrees onto temporary rest piers, offering a considerable savings in temporary trestle and allowing the drawspan to remain operable for navigation.

Slide 12—The Rob Roy bridge showing the new lift span in place over the relocated channel.

Slide 13—The Rob Roy bridge as completed and in service. Farther downstream can be seen Lock & Dam No. 4.

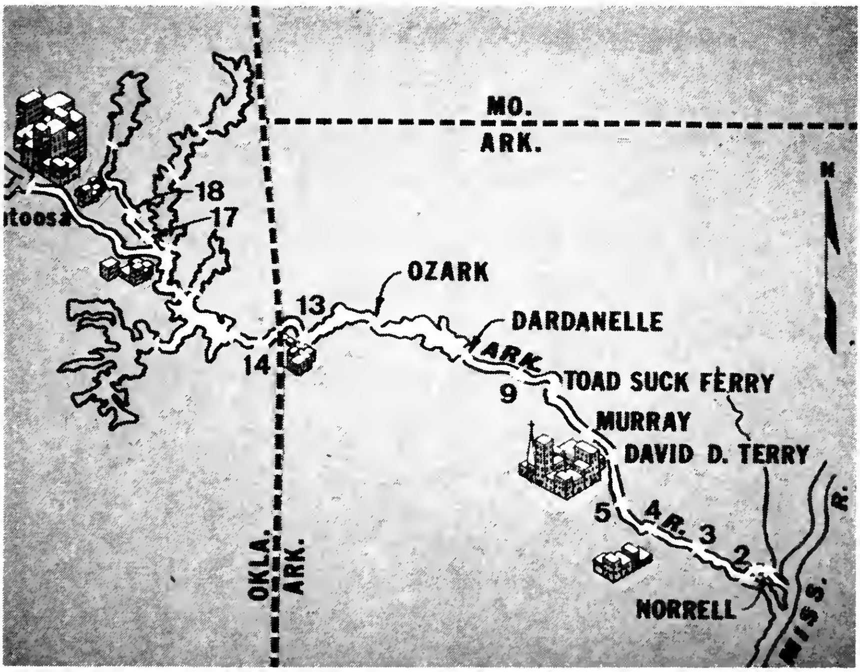
Slide 14—A view of Missouri Pacific's bridge over the White River at Benzal, Ark., just below Lock No. 1, prior to start of construction.

Slide 15—The Benzal bridge during construction showing installation of the cofferdam for the new south rest pier.

Slide 16—A view of the Benzal bridge at the present stage of construction. The two new rest piers are completed. The new vertical lift span is presently being assembled on transporter barges with change-out of spans now scheduled for July 1, 1973 and completion of the job early in 1974.

To date, the Arkansas River navigation project has required the expenditure of some one billion, three hundred million dollars of public funds. There is an interesting point associated with this expenditure. It has been estimated that had these funds been made available to the railroads serving the area, equivalent or superior service could have been made available to the various communities and industries for a minimum of 100 years at no service cost whatsoever. Free railroad service for one hundred years!

We have seen the changes in the railroad bridges over the Arkansas River navigation project. The problems involved were basically similar—the existing vertical lifts, relocation of the navigation channel and the necessity for temporary operation over shoofly structures. The outgrowth of the reconstructions has another similarity—the drawspans are operated by remote control without a bridge tender physically present at the bridge. For discussion of this feature we will limit ourselves, in the interest of time, to the operation of Missouri Pacific's two bridges at Little Rock—the Baring Cross bridge and the Junction Bridge. A. E. Schmidt, member of Committee 15 and the project engineer with Sverdrup and Parcel & Associates has been intimately associated with the Arkansas River bridges since the inception of the project. Mr. Schmidt will describe the remote control operation of Missouri Pacific's two bridges at Little Rock.



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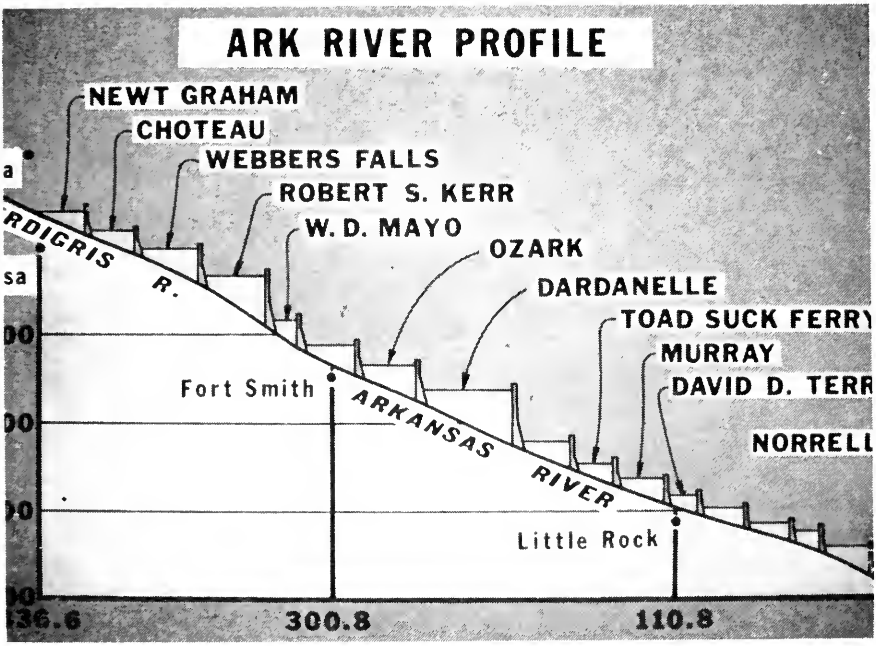

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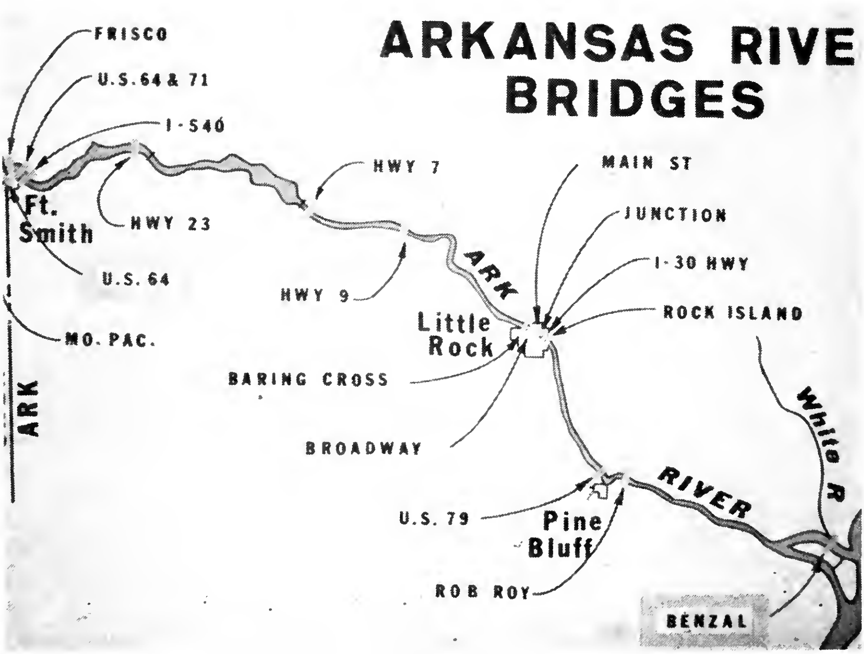

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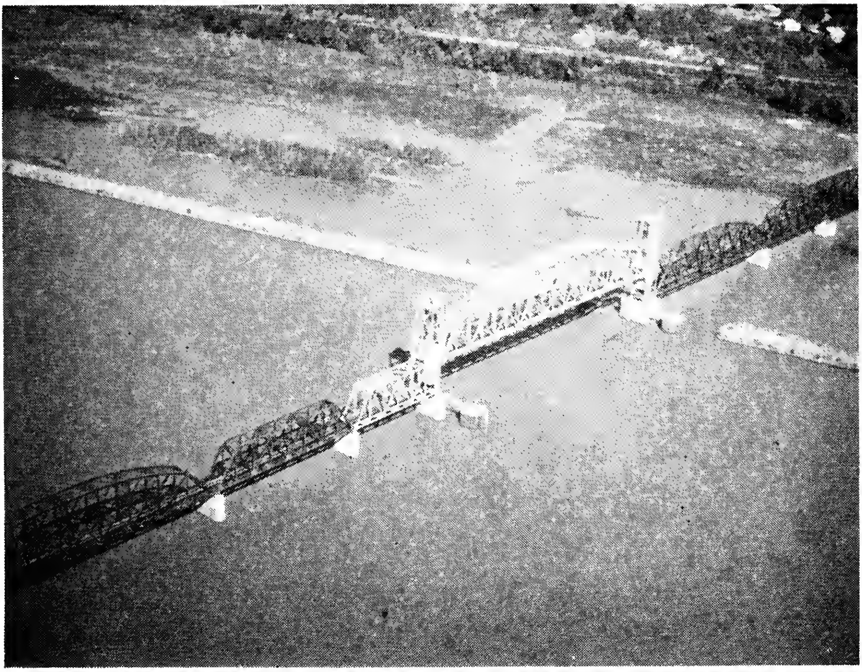

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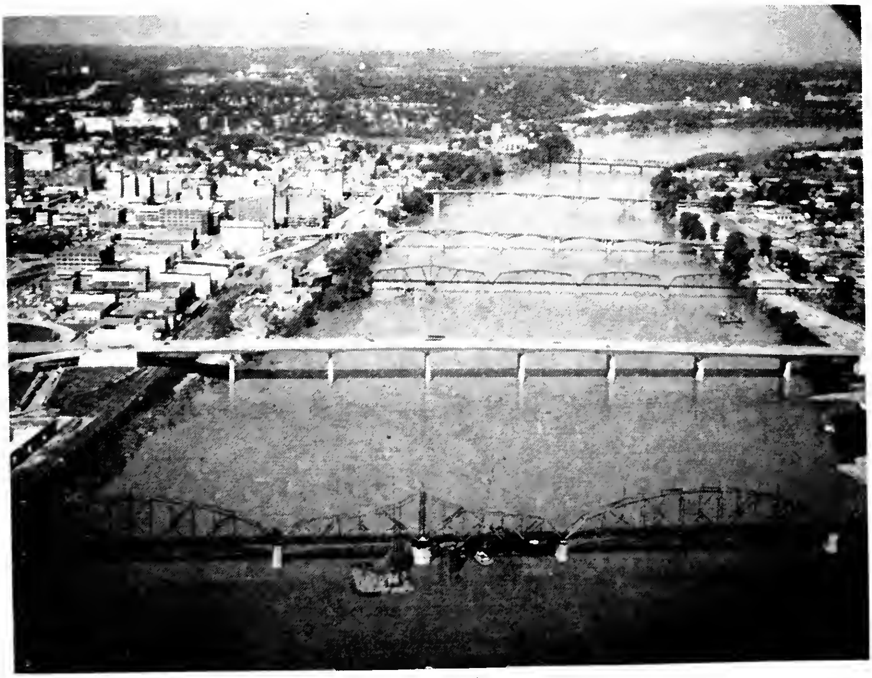

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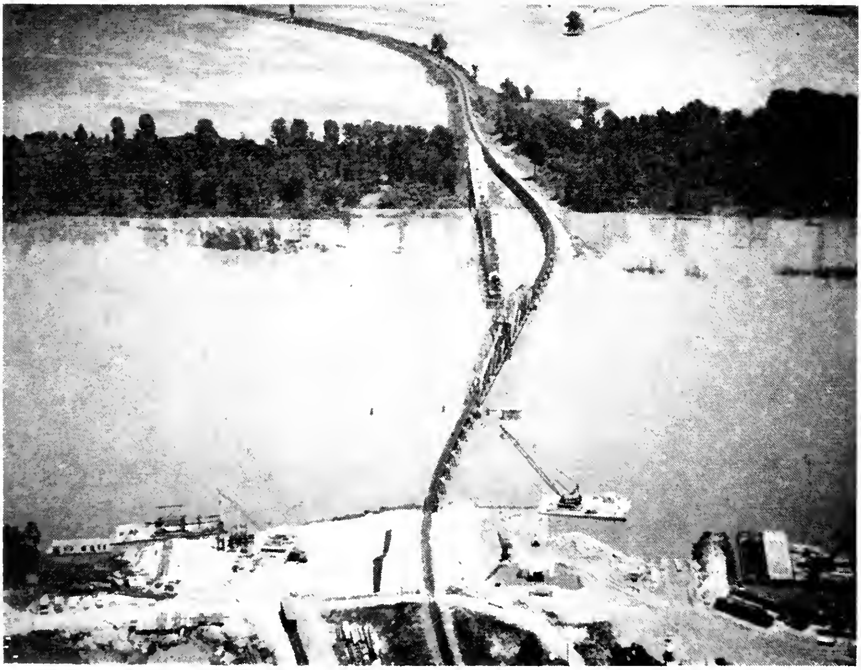

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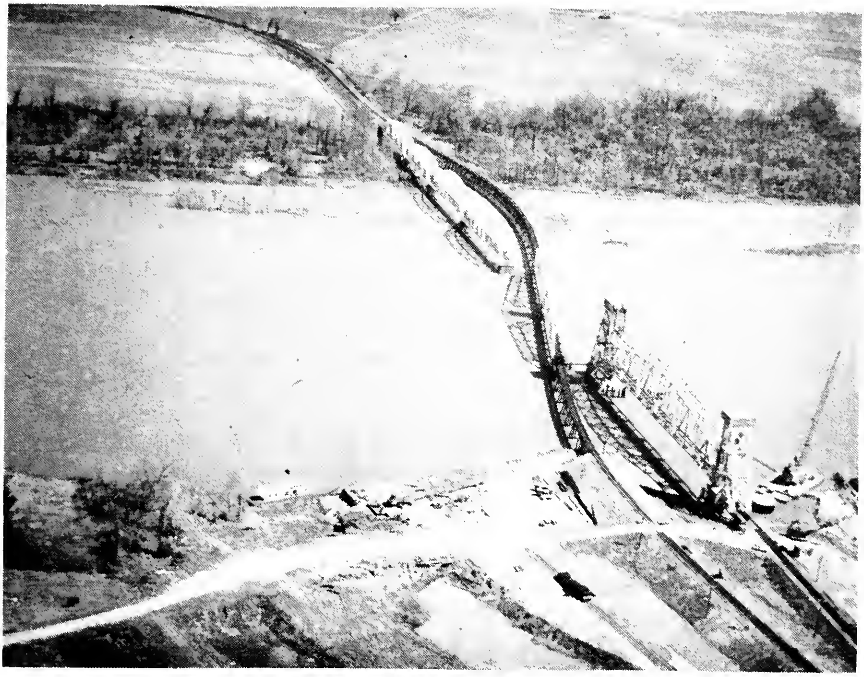

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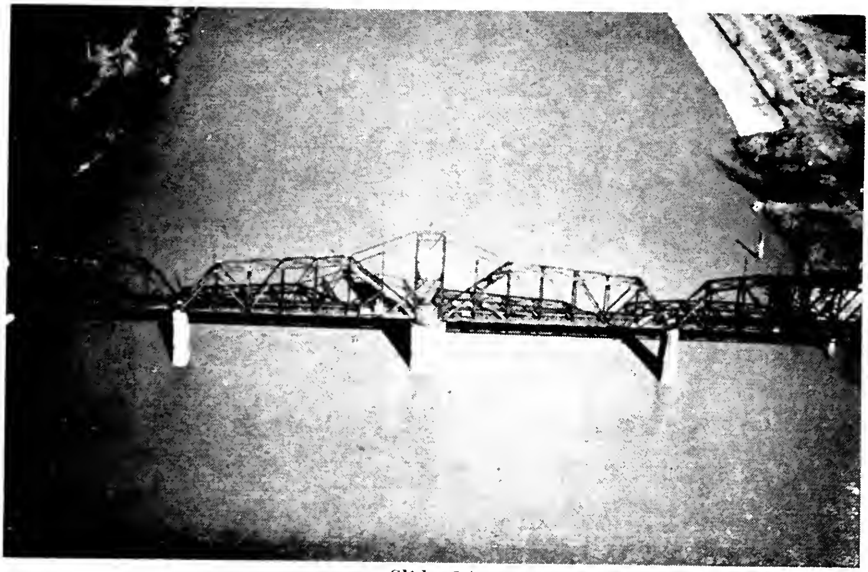

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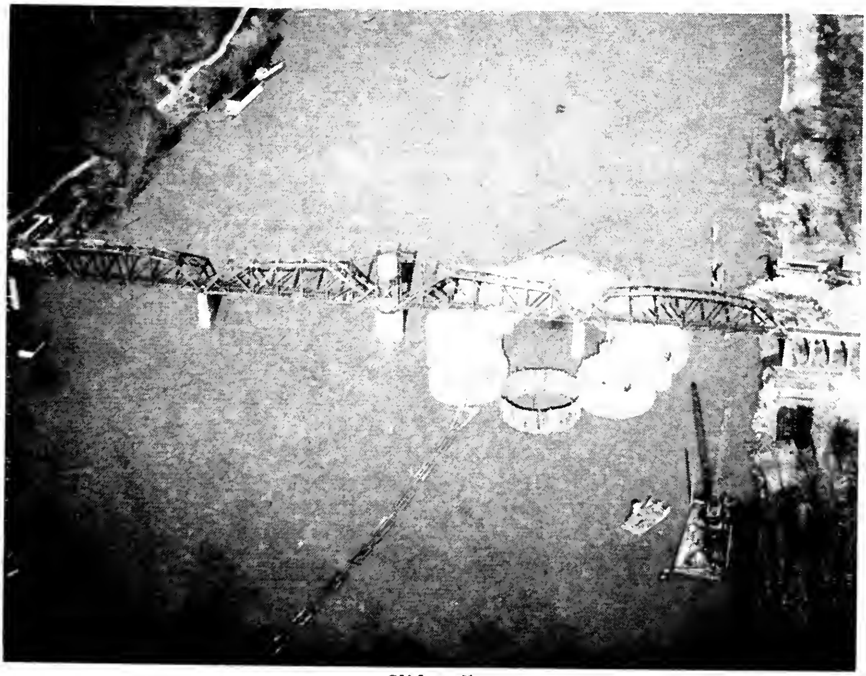


Slide 15.

Slide 16.

Development and Design of Remote Control Systems for Movable Bridges

74–643–4

By A. E. SCHMIDT

Project Engineer, Sverdrup & Parcel and Associates, Inc.

In late 1965 and early 1966, Sverdrup & Parcel entered into several contracts with the Little Rock District of the Corps of Engineers to prepare design memorandums for the alterations of six railroad bridges crossing the Arkansas River Navigation project. At the request of the railroads, our contracts required that a study be made of the feasibility of providing a system of automation for the movable spans. A specific system was to be established for each bridge and cost estimates developed.

Vertical lift spans which could normally be left in the open position had already been automated. The movable spans are automatically lowered and raised by means of track circuits which are activated by the train. The Frisco bridge over the Black Warrior River near Demopolis, Ala., is a notable example of this type of automation. We are utilizing a similar system on Missouri Pacific's Benzal Bridge over the White River. We were unable to find a case where a span had been

Note: Discussion open until October 15, 1973.

automated, which, due to a high volume of rail traffic vs. a low volume of barge traffic, was normally in the closed position. It was our solution to this situation which I would like to describe today.

In developing the system, we had discussions with the railroads, barge operators, the Corps of Engineers and the Coast Guard. The only specific requirement the Governmental agencies had was that river traffic had the right-of-way over train traffic.

We considered the possibility of automatic operation of the span which might be initiated by the approach of river traffic or by a signal originated by the towboat pilot, using radio, light beams or audio tones. We concluded that automatic initiation merely from the presence and motion of a river vessel would involve many complications, extensive development and expensive equipment—and we questioned the reliability of such a system. The barge companies would have been reluctant to provide special radio equipment to operate the span. Although searchlights are standard equipment on towboats, only some would be strong enough to operate the span from a safe distance, and these lights would have to be coded to provide postive recognition of a bona fide calling vessel. The most dependable device would have been the boat horn. These were technical problems; we did not investigate the legal ramifications of the barge company operating the railroad's span.

We also concluded that the safest and most dependable operation would be performed by a person having a direct knowledge of river conditions and up-to-the-minute information regarding train movements. On non-automated bridges this is the bridge tender. However, if a train dispatcher at his normal station could be furnished with the necessary information on the river traffic, he could operate the span safely and reliably. This is the system we developed; through a series of audible signals and visual displays originating from the bridge, the dispatcher operates the span. Instead of being "automation", it is actually a remote control system similar to the railroad's centralized traffic control and the systems used in oil and water distribution and power generating plants.

There were no operating regulations in effect for the Arkansas River so we assumed that the standard Mississippi River calling procedures would be used; namely, that the call to open a bridge would be one long blast on the boat horn and that the affirmative reply would be one long blast on the bridge horn. A delay in opening the span would be indicated by four short blasts of the bridge horn. At the time our study was made, there was no requirement that towboats be equipped with radios. Inasmuch as all large towboats normally carried several types of communication equipment, we recommended that the dispatcher be furnished a radio transmitter and receiver so that pilots could communicate directly with him. It is now a federal law that towboats be equipped with FM transmitter/receivers and the Coast Guard is now drafting the regulation.

I would like to describe the various components of the remote control system and later we will put it all together and go through a sequence of normal operation.

The vertical lift span bridges we designed for the Missouri Pacific and the Cotton Belt are tower drives. Operations are fully-automatic and controls are completely interlocked to insure the proper sequence of operation. I won't go into the type of speed control and skew protection devices used, since this would probably generate an argument with the electrical engineers in the audience whom I am ill-equipped to debate. A number of systems are available for this important aspect of remote span operation. I'll concentrate on the remote control system itself.

In addition to the navigation lights prescribed by the Coast Guard, the bridges are equipped with a system of white and amber lights which we call acknowledging and warning lights and whose function will be described later during the operating sequence.

Electrically operated heavy-duty compressor-type air trumpets are installed on one of the towers. These are sounded *once* to advise the pilot that the span will be opened or *four times* to indicate that the span cannot be opened immediately.

Directional microphones with parabolic dish antennas are installed at the bridge on pier protection cells. These are aimed upstream and downstream at the center of the channel at a point about 1200 ft from the bridge. The dispatcher is a busy individual and the railroads did not want him distracted by having to constantly monitor the river sounds. We designed a pulse relay train which will permit him to maintain the speakers at a very low sound level; pilots will be required to sound three blasts of their horn within a 10-second period to alert the dispatcher that they will request a span opening. Responding to this coded call, this interposed circuit causes the volume to be automatically turned up on the sound channel speakers, a buzzer sounds and a light flashes on the operator's console. Two speakers are provided which are jointly in service, but a selector switch will permit disconnection of a speaker to give the operator an indication of the direction of movements on the river.

Two television cameras are mounted within one machinery house, one aimed upstream and one downstream. These cameras do not have a panning capability and there is a blind spot in the immediate area of the lift span. However, most tows will be long enough so that either the bow or stern will be in view as it passes through the opened span.

Extremely high resolution television cameras were developed during the Vietnam war and are now on the market. Some thought was given to changing the cameras supplied under the contract to this more sensitive model but the costs were quite high. At the time of our investigation, these new cameras were about $15,000 each as compared to about $1400 for the model installed. Serious consideration should be given to this type of camera in future installations due to improved vision at night and in fog.

We were asked to also consider radar as a visual aid in lieu of closed-circuit television. The distinct advantage of radar is that it is not affected by fog or darkness. However, the amorphous electronic image displayed on the radar scope requires interpretation by the operator, as compared to the photographic image displayed on the tv monitor. Also, direct transmission of radar signals to a scope almost two miles away was not feasible—it would have been necessary to locate the scope close to the scanner and transmit the image to the dispatcher's station by television. In the Little Rock reach, there are highway bridges about 1000 ft upstream and downstream of the Junction Bridge which would have limited the effective radar coverage. We would not, however, summarily dismiss radar as a possibility on other installations.

To detect the presence of a boat under the span, and to prevent the span from being lowered on a boat, we have what we call, for lack of a better term, a boat-detector system. In the design memorandum, we recommended that a microwave system be investigated for that purpose and suggested a modest development program. There were no research and development funds available, however, and we are utilizing photoelectric cells for this purpose. So far, if the lenses of the housing tubes are clean, the system has functioned during heavy rains and fog. It does have a fail-safe feature, however; if the beam is blocked, whether by a boat or atmospheric conditions, the lift span cannot be lowered by the dispatcher. If the beam is blocked while the span is descending, the span is automatically stopped, and reversed back to the fully open position. The remote control operator cannot override this feature. There is a complete control system at the bridge as with any bridge tender operation. When the span is operated from the bridge, the boat-detector system can be bypassed since the operator can tell whether the channel is clear. There may be times when the dispatcher must call for help and the span has to be operated from the bridge control house.

The boat-detector system must function through the complete range of river levels at which barges are expected to operate. In the Little Rock reach this range is about 17 ft. Eight sealed tubes are embedded in each of the two channel piers in a vertical pattern. Transmitters and receivers are aimed through glass ports in the tubes. By a float arrangement, the transmitter immediately above the water level is energized.

Last, but certainly not least, the dispatcher has a four-channel FM radio transceiver. He continuously monitors channel 16, 156.8 megahertz, and direct voice communication between the pilot or the lockmasters is possible over four FM channels. We believe that in time this will become the primary means for requesting a span opening and the horn signal will be its backup.

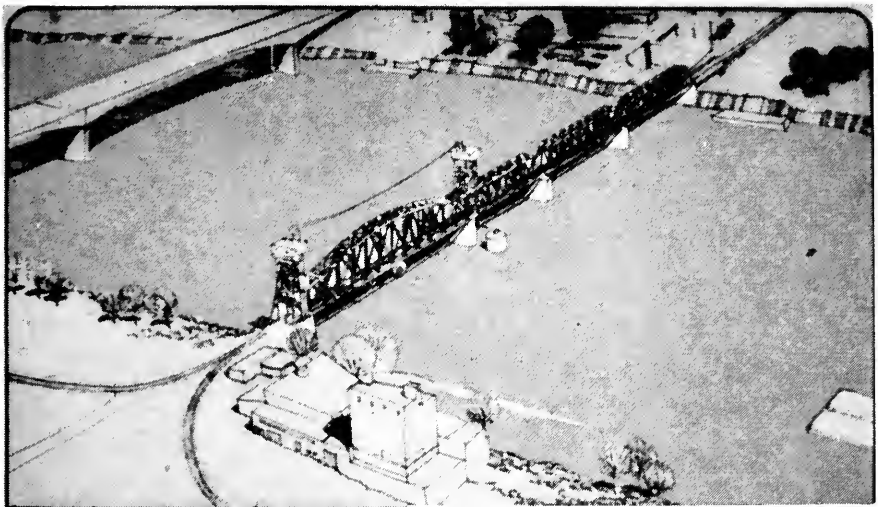
Now, by a series of slides, I would like to show you a typical remote-control operation. These are action–reaction type drawings showing what is happening on the river and at the remote control station. What is shown depicts operation of a single span by the dispatcher, but at Little Rock, Missouri Pacific's dispatcher will actually operate two spans on bridges about 0.9 miles apart, and his console has separate controls and displays for each bridge.

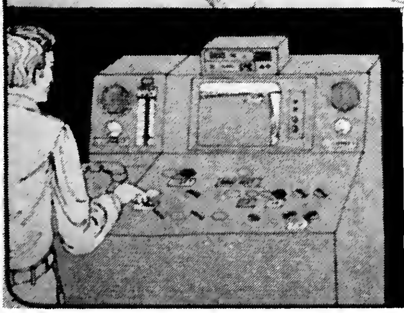
I would like to be able to report that the system is in operation and functioning well. However, certain field modifications are being made to improve the sound system. Additional filters are being added to filter out low-frequency noises from the wind and truck traffic on adjacent bridges to improve the operation of the pulse relay train which alerts the dispatcher.

On the first-installed cameras at the Little Rock bridges, the orientation required on these cameras resulted in sunlight being reflected off the water and into the cameras at certain times of the year and at certain periods of the day. This resulted in a small area of the videcon being burned, and filters have been installed which are activated by photoelectric cells to prevent this in the future.

The total cost of the remote control system for these two bridges is about $270,000, and it is estimated that the cost of the system can be amortized in 5 or 6 years.

We believe that this system will function efficiently and reliably—and we're looking forward to a full-scale test.



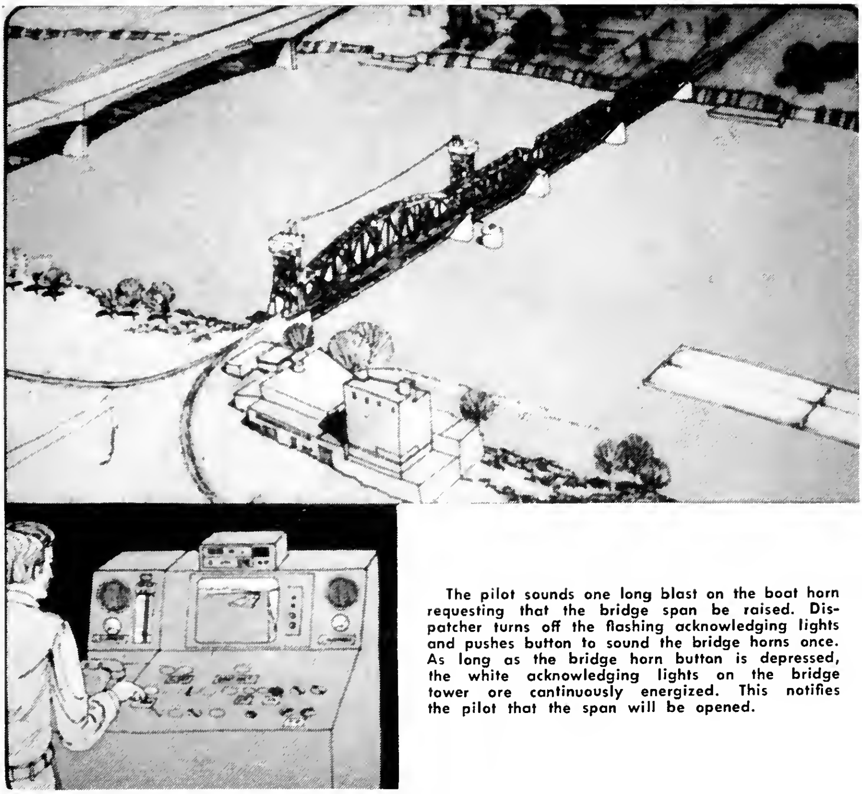


The dispatcher normally monitors river sounds at a low-volume level which originate from directional microphones at the bridge. As a vessel approaches the bridge, the pilot sounds the boat horn three times to alert the dispatcher.

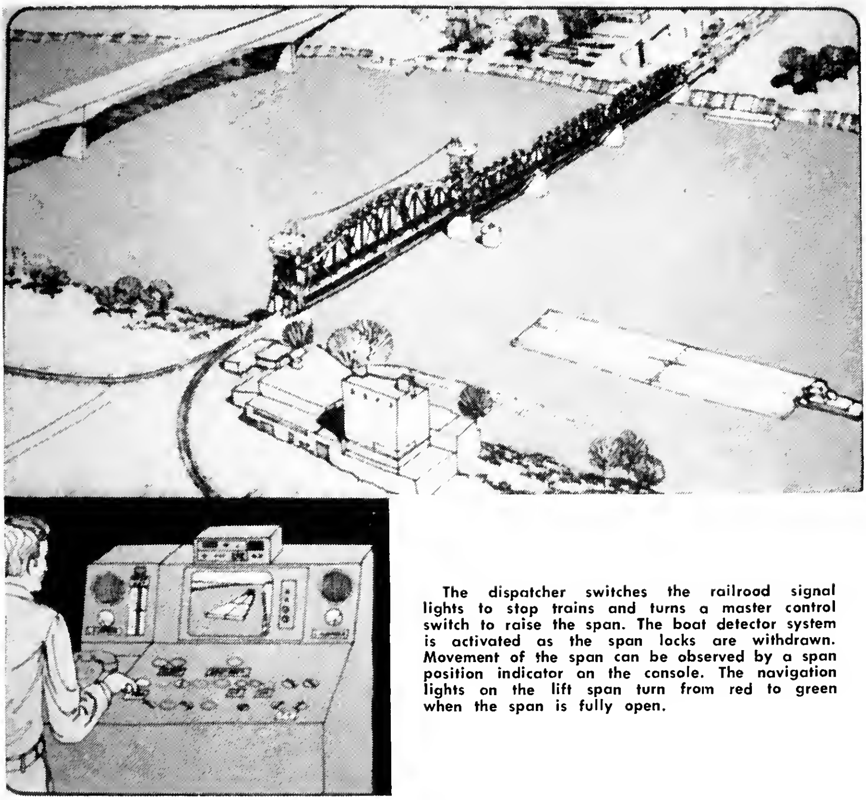
Equipment rejects other signals but accepts the three blasts and automatically turns up the volume of the sound channel speakers. This signal also sounds a buzzer and starts an indicator light flashing on the control console in the dispatcher's office.

With one motion, the dispatcher silences the buzzer, turns off the console light and starts the white acknowledging lights flashing on the bridge tower. This acknowledges to the pilot that his approach is known. The dispatcher turns on the television monitor to watch the approach of the vessel.

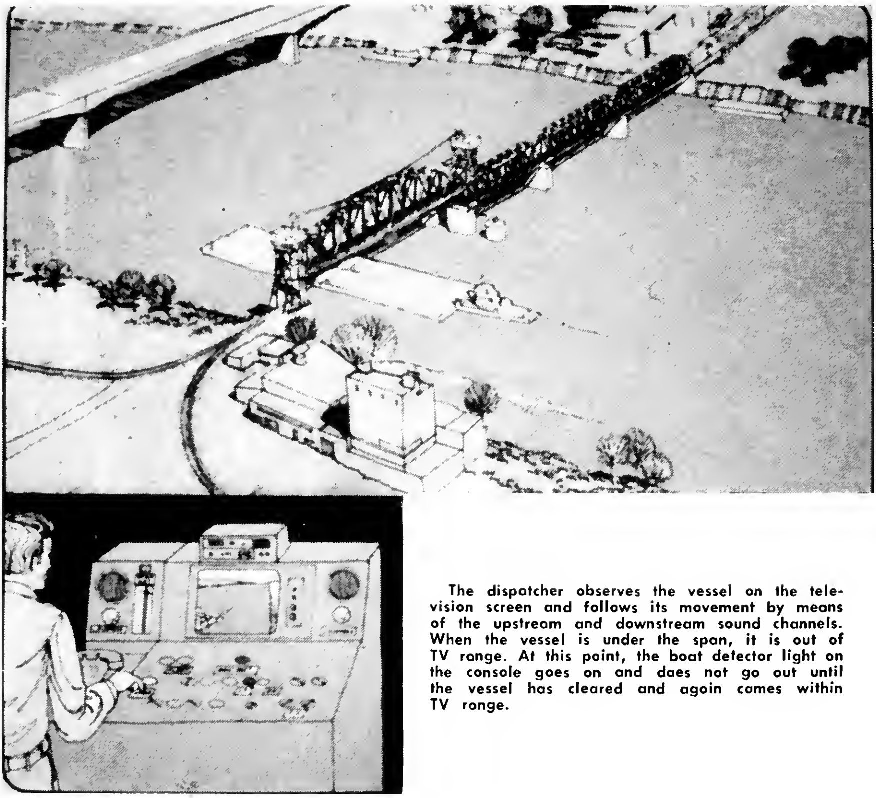
Slide 1.


The pilot sounds one long blast on the boat horn requesting that the bridge span be raised. Dispatcher turns off the flashing acknowledging lights and pushes button to sound the bridge horns once. As long as the bridge horn button is depressed, the white acknowledging lights on the bridge tower are continuously energized. This notifies the pilot that the span will be opened.

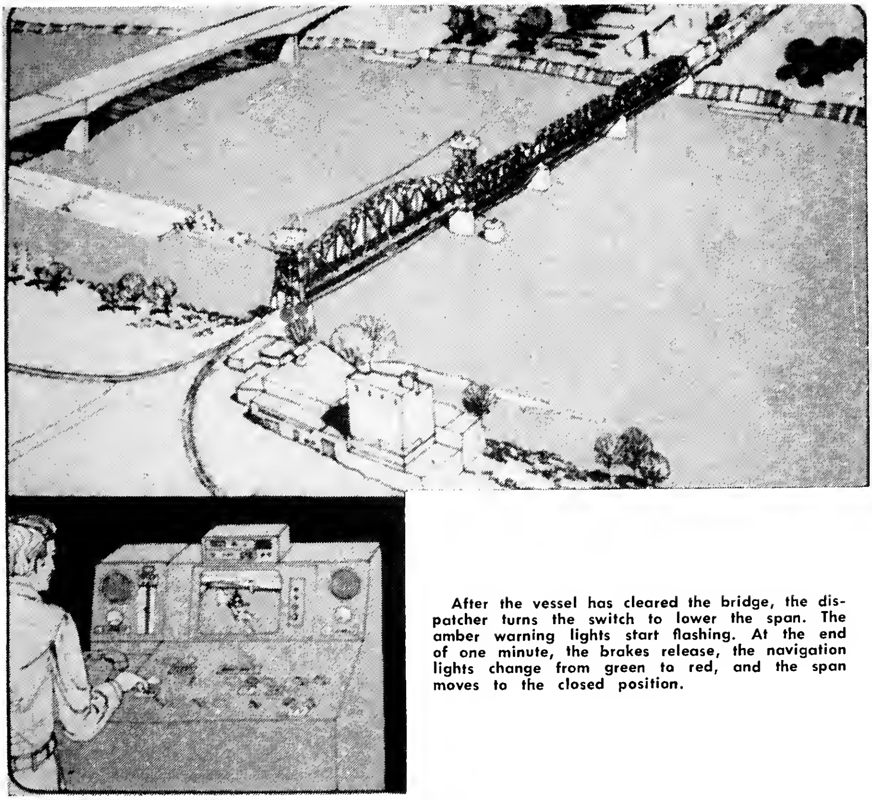
Slide 2.


The dispatcher switches the railroad signal lights to stop trains and turns a master control switch to raise the span. The boat detector system is activated as the span locks are withdrawn. Movement of the span can be observed by a span position indicator on the console. The navigation lights on the lift span turn from red to green when the span is fully open.

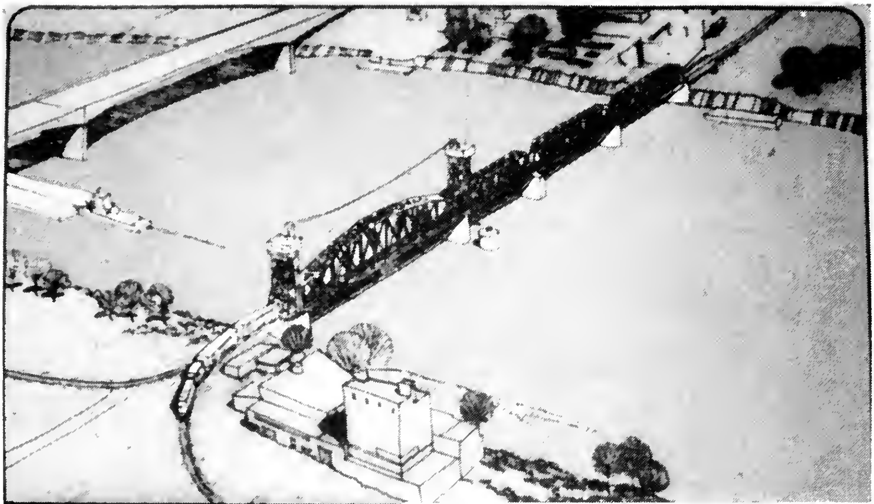
Slide 3.

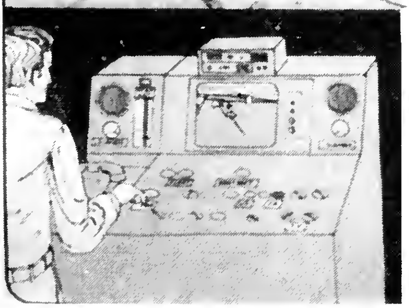

The dispatcher observes the vessel on the television screen and follows its movement by means of the upstream and downstream sound channels. When the vessel is under the span, it is out of TV range. At this point, the boat detector light on the console goes on and does not go out until the vessel has cleared and again comes within TV range.

Slide 4.


After the vessel has cleared the bridge, the dispatcher turns the switch to lower the span. The amber warning lights start flashing. At the end of one minute, the brakes release, the navigation lights change from green to red, and the span moves to the closed position.

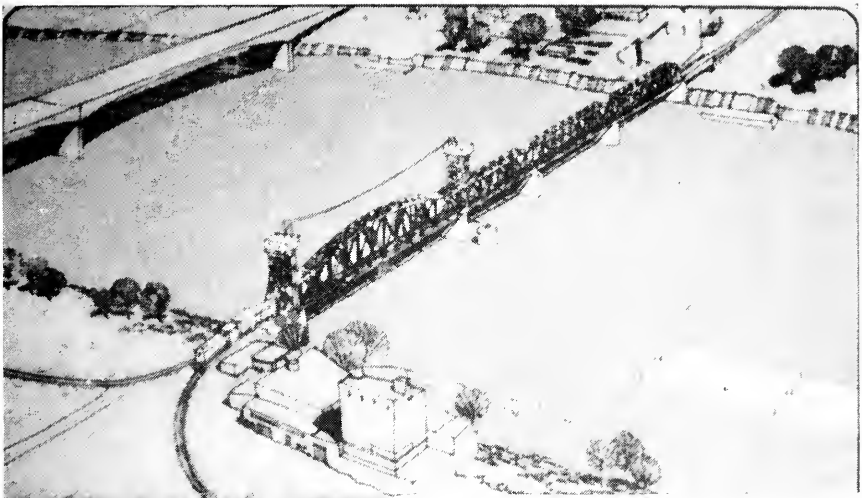
Slide 5.

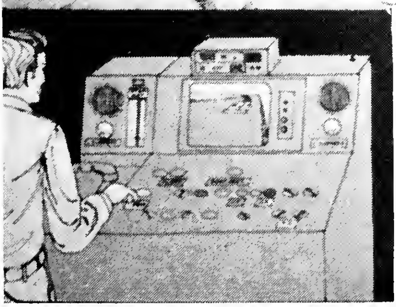




The flashing amber lights go off and the console lights indicate that the span is seated and locked in position. The dispatcher changes the railroad signal lights to permit rail traffic to cross the bridge, and restores the console equipment to the original monitoring condition.

If a train is approaching the bridge and has passed the last check point the dispatcher turns on the amber warning lights, and sounds the bridge horn four times. This tells the pilot that the span cannot be opened immediately. The pilot acknowledges by sounding four blasts on the boat horn and stands by.





After the bridge is cleared of rail traffic, the dispatcher turns off the flashing amber lights and sounds the bridge horn once, indicating he is ready to proceed.

Dispatcher and pilot follow the same procedure as outlined before.

Full Scale Tests to Failure of Four Highway Bridges

74–643–5

By DAVID W. GOODPASTURE and EDWIN G. BURDETTE
The University of Tennessee

Introduction

Background Information

Four deck-girder highway bridges in Tennessee, located in an area which has since been flooded as a part of the Tennessee Valley Authority's Tims Ford Reservoir, were made available by the Tennessee Department of Transportation and Tennessee Valley Authority (TVA) for testing purposes. The major portion of the testing, which included tests to failure, was performed during the summer of 1970 as a part of a research contract between The University of Tennessee's Civil Engineering Department and the Tennessee Department of Transportation, in cooperation with the Federal Highway Administration (FHWA).

Prior to the tests to failure, various tests relating to the dynamic behavior of the bridges were performed. One series of tests was performed by the Federal Highway Administration, the Department of the Army, the Tennessee Department of Transportation and The University of Tennessee during the spring of 1969. These tests included loadings caused by a 100,000-lb M-60 combat tank and the tank plus its transporter with a total weight of 195,400 lb. Additional tests involving truck loadings and vibratory loads were conducted during the summer of 1970. A complete description of the testing program and a compilation of the test results are given in the Final Report for this research project[(1)*], and a detailed analysis of the results of the static tests to failure is given in Reference 2.

Objectives of the Research

The overall objective of the research reported herein was to evaluate certain bridge design criteria by conducting tests on the four bridges mentioned earlier. Specifically, this research project was directed toward consideration of design criteria related to three facets of design: (1) lateral distribution of load, (2) dynamic response of the bridges subjected to both rolling loads and vibratory loading, and (3) ultimate strength and mode of failure of each of the four bridges.

Scope of this Report

Three types of loadings were used in the testing program: (1) rolling loads, in which an HS 20 loading and a load almost twice an HS 20 loading were simulated; (2) vibratory loads, which were performed by the FHWA using its vibration generating equipment; and (3) static loads, which were applied by means of a rock anchor system. This report will describe the tests and partial results obtained in the first and third types of loading conditions mentioned above.

Description of Bridges

Each of the four bridges was a two-lane deck girder bridge with four longitudinal girders. A description of the bridges is given in Table I, and photographs of the bridges are shown in Figs. 1 and 2.

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* Superscript numbers in parentheses refer to similarly numbered references at the end of this paper.

Note: Discussion open until October 15, 1973.

TABLE I

DESCRIPTION OF BRIDGES

Bridge Number	General Description	Span	Girder Spacing	Skew	Location	Design Loading and Date
1	4-Span Continuous, 36" Steel Rolled Beams, Composite in Positive Moment Regions	70'-90'-90'-70'	8' - 4"	90°	Tenn. Rt. 130 over Elk River	HS-20 1963
2	Simple Span Composite with AASHO Type III Precast, Prestressed Concrete Beams	66'	8' - 10"[a]	70°	Tenn. Rt. 130 over Boiling Fork Creek	HS-20 1963
3	Simple Span Reinforced Concrete T-Beams, Monolithic Construction	50'	6' - 10"	60°	US 41A over Elk River	H-15 1938
4	3-Span Continuous, Non-Composite, 27" Steel Rolled Beams	45'-60'-45'	7' - 4"	90°	Mansford Road over Elk River	H-15 1956

[a]Varies due to 4 1/2 degree horizontal curve.

From a testing viewpoint, Bridges 1 and 4 were the most useful of the four bridges. Bridge 1 was on a flat sag vertical curve; but in all other respects these two bridges were ideal for testing: 90° skew, horizontal tangent, almost zero grade, recent construction.

Bridge 2, composed of AASHO Type III precast, prestressed sections, was also of recent design and was a widely used type. Its usefulness as a test specimen, however, was limited somewhat by the presence of a 70° skew, a grade of approximately 4½ percent, and a superelevated roadway due to a 4½° horizontal curve. Although Bridge 3 was not of recent design and had a 60° skew, it had a zero grade and was not curved. Also, the reinforced concrete T-beam construction is representative of a number of bridges presently in use all over the United States.

Test Procedure for Dynamic Tests

Introduction

The dynamic behavior of the bridges included in this study was examined in three distinct phases. Initially, the Federal Highway Administration, Department of the Army, Tennessee Highway Department and The University of Tennessee cooperated in a study that included the testing of Bridges 1, 2, and 3. These tests utilized an HS 20 loading, a M-60 combat tank, and an HET-70 tank transporter. Emphasis was placed on the lateral distribution of load to the girders due to these loadings and also to the magnitude of the live load stresses caused by the heavy vehicles[3,4,5].

A second phase of the study relative to the dynamic behavior of the bridges included in this report was conducted by the Federal Highway Administration with the aid of the Tennessee Highway Department and The University of Tennessee.

Fig. 1 (a)—Bridge 1.

Fig. 1 (b)—Bridge 2.

Fig. 2 (a)—Bridge 3.

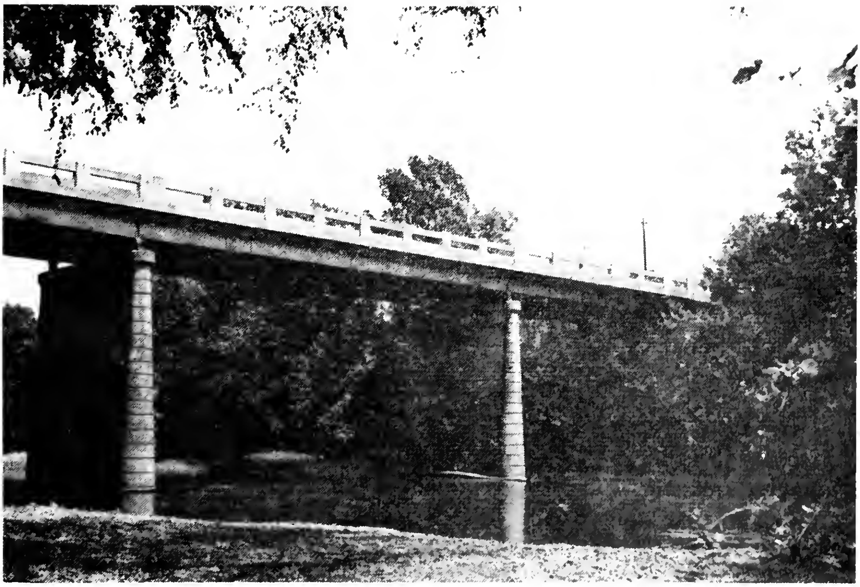


Fig. 2 (b)—Bridge 4.

This phase included the experimental study of the resonant vibration responses of Bridges 1, 2, and 4 due to excitation of the bridges by a pair of variable frequency harmonic force generators installed on each bridge. A description of the equipment and results obtained is contained in Reference 6. In addition, one of the reinforced concrete T-beam approach spans (28 ft) to Bridge 4 was tested, and the results are reported in Reference 6.

The third phase of the investigation of the dynamic behavior of the bridges included in the project dealt with the response of Bridges 1, 2, and 4 to three truck loadings.

The purpose of conducting rolling-load tests was threefold:

(1) These tests would provide information regarding the dynamic response of the bridges both to typical truck loadings and to trucks with large overloads;

(2) Information would be provided with regard to the maximum stress levels induced in the supporting members of the bridges due to the loadings described; and

(3) These tests would provide information with regard to the lateral distribution of load to supporting bridge girders.

Test Vehicles

Two test vehicles were used to provide three different loadings: (1) the FHWA truck which simulates an HS 20 loading (FHWA-HS 20), (2) a truck provided by The University of Tennessee simulating an HS 20 loading (UT-HS 20), and (3) The University of Tennessee truck loaded to 132.5 kips, a loading which is referred to herein as a "UT-HS 40" loading. Diagrams indicating the magnitudes and spacings of these three vehicle loadings are shown in Fig. 3.

The vehicles just described were utilized alone and together on the bridges for 70 tests with variables including the speed and position of the vehicles. In general the vehicles were each used in three transverse positions (or lanes), namely, the left and right lanes and down the center of the bridge.

Results of Dynamic Tests

Several of the conclusions reported in Reference 1 are given below.

(1) The rolling-load data suggest that, for a particular bridge, the lateral distribution of load depends almost entirely on the lateral position of the load on the bridge. While axle spacing, magnitude of truck load, and vehicle speed have a measurable effect on the total moment at a bridge cross-section, these parameters appear to have only a minor effect on the lateral distribution of load to supporting girders.

(2) In general it was found that the strain in the main girders of each bridge was increased slightly when the vehicle crossed the bridges at speeds greater than the crawl speed, but the strains did not always increase with increased speed and notable exceptions to this general statement were found in all three bridges. Therefore, any general conclusion relative to the effect of speed on the increase in strain in the main girders of each bridge was not justified.

(3) The increase in strain in the main girders, particularly those nearest and most influenced by the load, due to the overloaded truck was apparent. The overload was approximately 90 percent greater than the standard

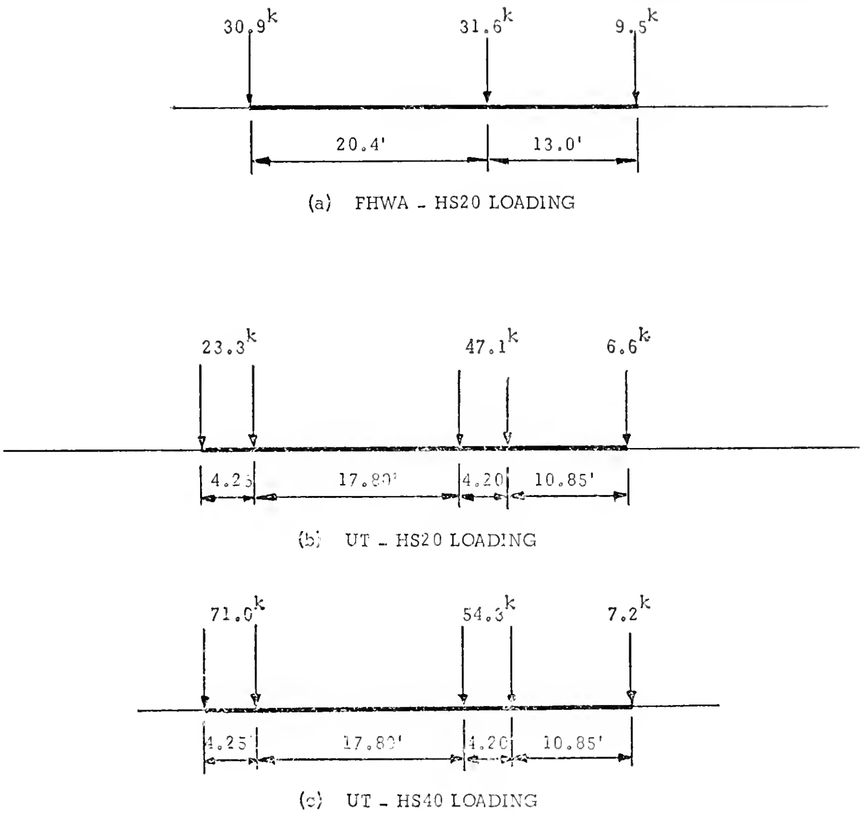


FIGURE 3. DIAGRAMS SHOWING TRUCK LOADINGS USED IN ROLLING LOAD TESTS.

HS 20 loading and the increase in strain was 90 percent, 30–100 percent, and 75–80 percent for Bridges 1, 2, and 4, respectively. Each of the bridges responded elastically to the overload, and no significant change in the lateral distribution of the strain to the girders was noted. The examination of several tests on Bridge 4 indicated that the superposition of results of two tests, each with a single vehicle on the bridge, compared favorably with the results of a test with two vehicles on the bridge simultaneously. The influence of superelevation of Bridge 2 was also apparent as evidenced by the fact that the lowest of two girders directly under the vehicle always experienced the largest strain.

Test Procedure for Static Tests

Placement of Loads

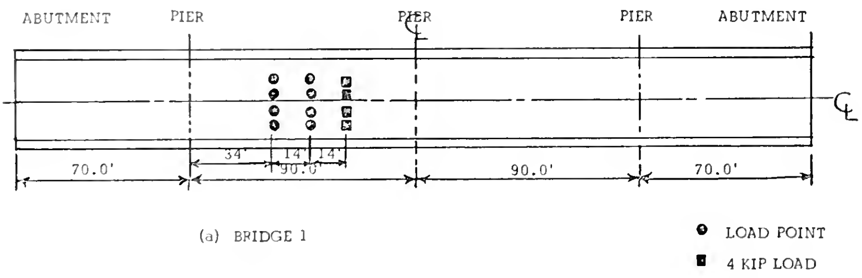
The loads were placed on each bridge with the exception of Bridge 4 in such a way as to simulate an HS truck in each lane, located to cause maximum positive moment near the center of the span. The points on the span at which load was applied were at the positions of the eight rear wheels of the two simulated trucks. For the test to failure of Bridge 1, the four front wheels were simulated by four 4000-lb pallets of concrete blocks. The simulation of front wheels was omitted for the other bridges. The positions of the applied loads for the four bridges are illustrated in Figs. 4 and 5. Because of difficulties in rock drilling, only six load points were used for Bridge 4, as shown in Fig. 4.

Application of Load

The loads required to cause bridge failure were developed through a "rock anchor system" and were applied to the bridge deck through a "bearing grill."

Rock anchor system. At each of the eight load points for each span, a hole was drilled through the concrete bridge deck. Directly below each one of these holes, a hole was drilled approximately 25 ft into the limestone rock, and an 18s reinforcing bar was grouted into place in this hole. A tremie pipe was used for grouting, and the grout was made from shrinkage-compensating cement using, approximately, a mix with 7 gal of water per sack. The bar was terminated below the bridge deck, with a connection accommodating a 1⅜-in.-diameter Stressteel bar being welded to the top end of the 18s bar.

After completion of all rolling-load and other tests on each bridge, a 1⅜-in-diameter Stressteel bar was connected to each of the 18s bars. The Stressteel bar extended through the hole in the bridge deck and through a 100-ton-capacity center-hole jack, which rested on a "bearing grill."



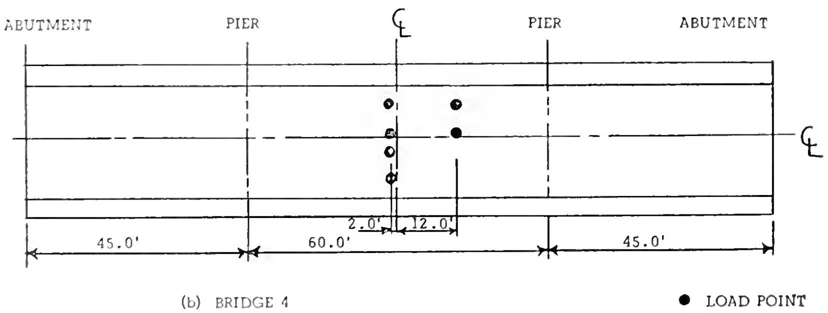
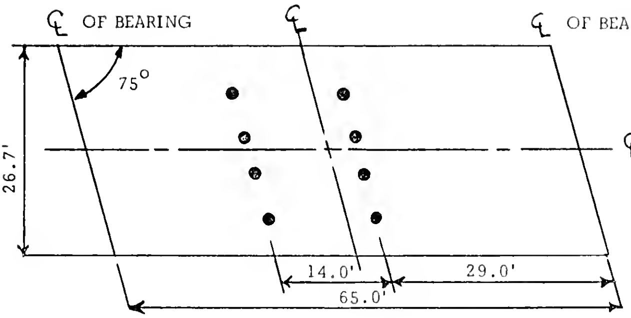
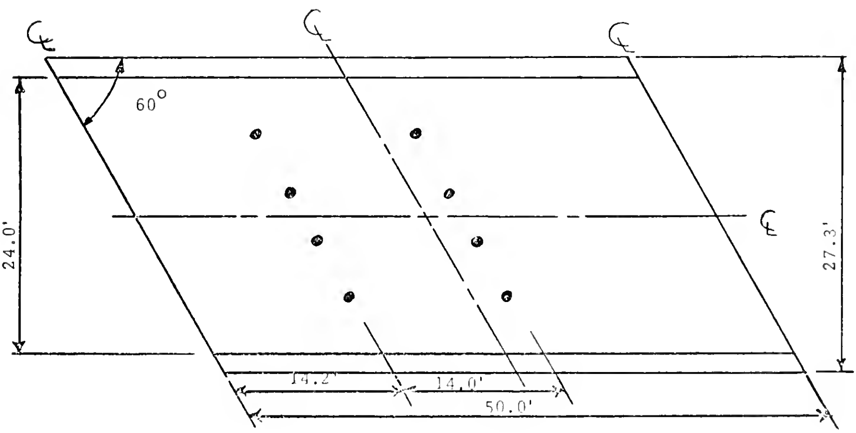


FIGURE 4. SKETCHES SHOWING POSITION OF LOADS USED IN TESTS - BRIDGES 1 & 4



(a) BRIDGE 2 ● LOADING POINTS



(b) BRIDGE 3 ● LOADING POINTS

FIGURE 5. SKETCHES SHOWING POSITION OF LOADS USED IN TESTS - BRIDGES 2 & 3

Bearing grill. The bearing grill consisted of two 14-in.-wide flange beams, 3 ft 10 in. long, spaced 2 ft 6 in. center-to-center. These beams were joined at the ends by two 12-in. channels, which spanned between the beams and were welded to the beams so that the bottom flanges of the channels were flush with the bottom surfaces of the beams in order to obtain uniform bearing. Two more channels spanned between the beams at the centers of their 3-ft 10-in. lengths and were fastened to the beam webs. The load was applied by the hydraulic rams through a 2-in.-thick steel bearing plate to these center channels. Soft wood 2 by 10's were placed under the beams and on the bridge deck, and 2 by 4's were placed under the end channels in order to minimize stress concentrations and reduce the likelihood of punching shear. In addition, it was necessary to cast concrete bearing pads on superelevated Bridge 2 in order to apply the loads to a horizontal surface.

Loading Procedure

The load was applied to each load point by a Stressteel center-hole ram acting on a bearing grill. The rams were activated by an electric pump equipped with a pressure gage which had a maximum capacity of 10,000 psi. The loads were applied in increments of 1000 psi up to near yielding and then in increments of 500 psi up to failure. The force in each bar was obtained from strain readings after each increment of load. Also, strains at various points in the bridge were monitored and level-rod readings at several points on the bridge deck were taken after each load increment.

The tests were discontinued at some point after the ultimate load of the bridges was attained. Ultimate load was defined in these tests as the maximum load attained in a test to "failure," and "failure" was said to have occurred when an increase in deflection of the bridge took place under a decreasing load.

Results of Static Tests

Behavior Mode of Failure

Each of the four bridges, with the exception of Bridge 2, failed in a flexural mode, and each bridge behaved in a ductile manner. Load-deflection curves for one point near the center line of the span on each bridge are shown in Figs. 6 to 9, and photographs illustrating the mode of failure of Bridges 1, 2, and 4 are shown in Figs. 10 and 11.

Bridge 1. The behavior of this bridge was almost linearly elastic up to yielding at the section under the applied loads nearest the center of the span. As the load was increased, there was considerable rotation at this section, and, in turn, considerable deflection. Shortly after yielding began and the load was increased further, the bridge "lifted off" the abutment nearest the applied load, thus making it impossible to develop more moment at the first pier.

The bridge continued to experience increasingly large deflections for each load increment until, after a very large deflection, yielding occurred and a plastic hinge formed at a section near the center pier at the end of the cover plates on the side of the pier away from the loaded span. Shortly after this hinge formed, a secondary compression failure of one of the curbs occurred at the section of maximum positive moment, and the test was terminated.

Bridge 2. This bridge behaved in a predictable way up to a load of approximately 950 kips. However, there was considerable "dishing" of the bridge at this

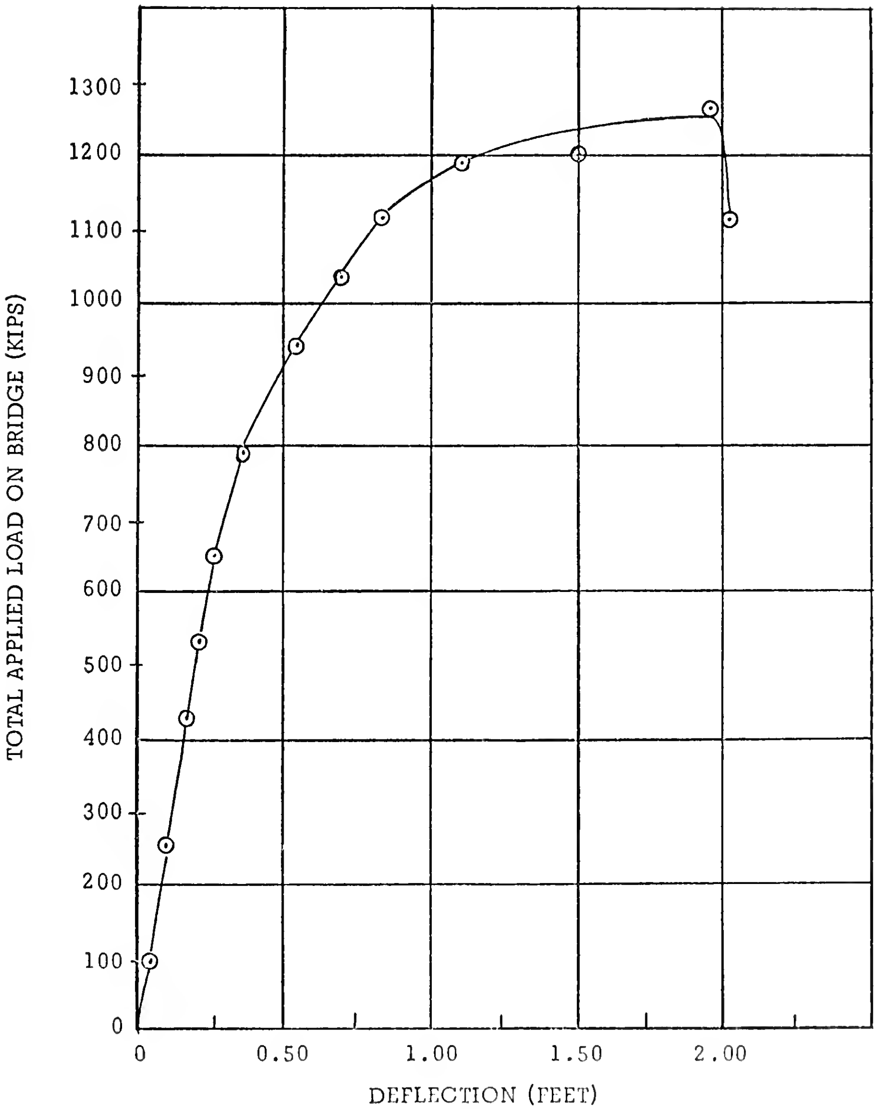


FIGURE 6. LOAD-DEFLECTION CURVE FOR BRIDGE 1

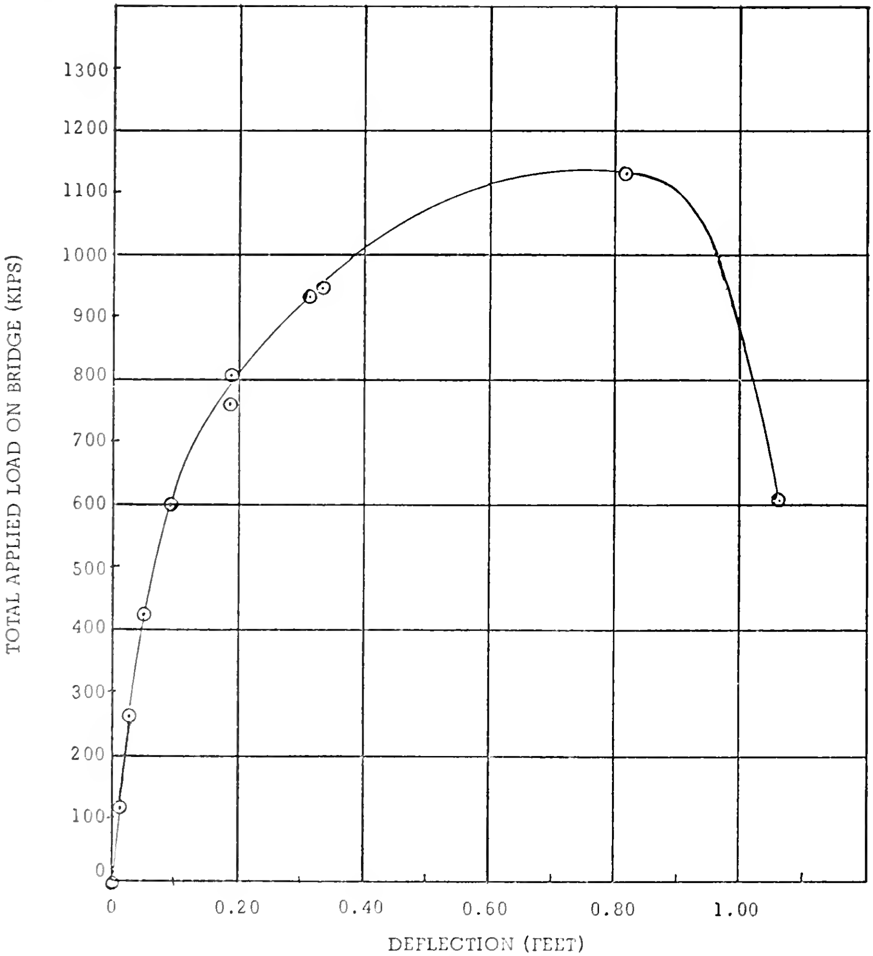


FIGURE 7. LOAD-DEFLECTION CURVE FOR BRIDGE 2

point, with the interior girders being deflected considerably more than the exterior. The result of this dishing was a tendency for the bridge deck to separate from the interior precast girders. At a load of approximately 950 kips this separation occurred, and composite action of the interior griders was lost as the vertical stirrups crossing the interface between girder and deck were sheared.

After composite action was lost, the behavior of the bridge was radically changed. Almost immediately there was crushing of the extreme top fibers of the interior precast sections at the section of maximum moment. This crushing and accompanying rotation resulted in a redistribution of moments at the section, with the moment in the exterior girders being increased. As the load was increased further, the interior girders failed in shear, and the test was terminated.

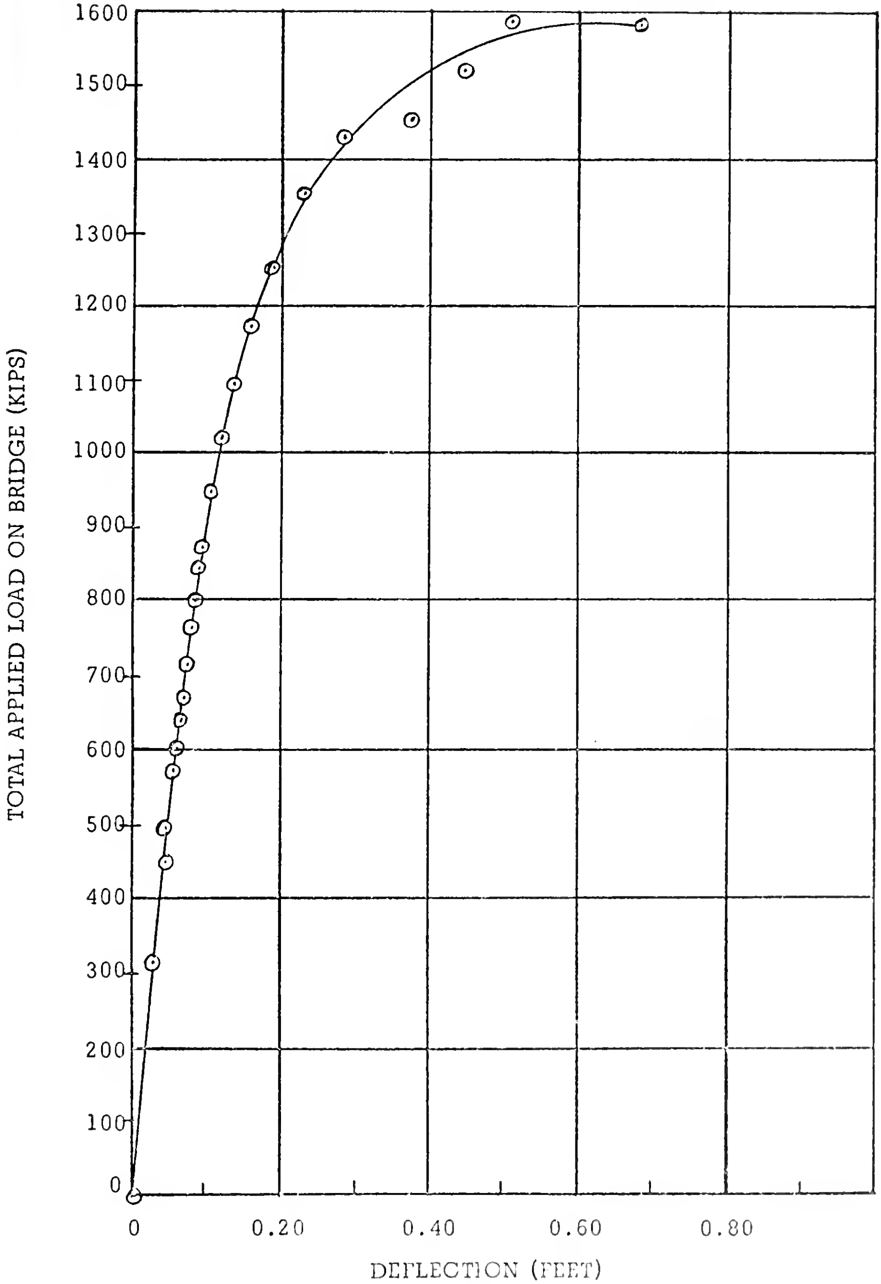


FIGURE 8. LOAD-DEFLECTION CURVE FOR BRIDGE 3

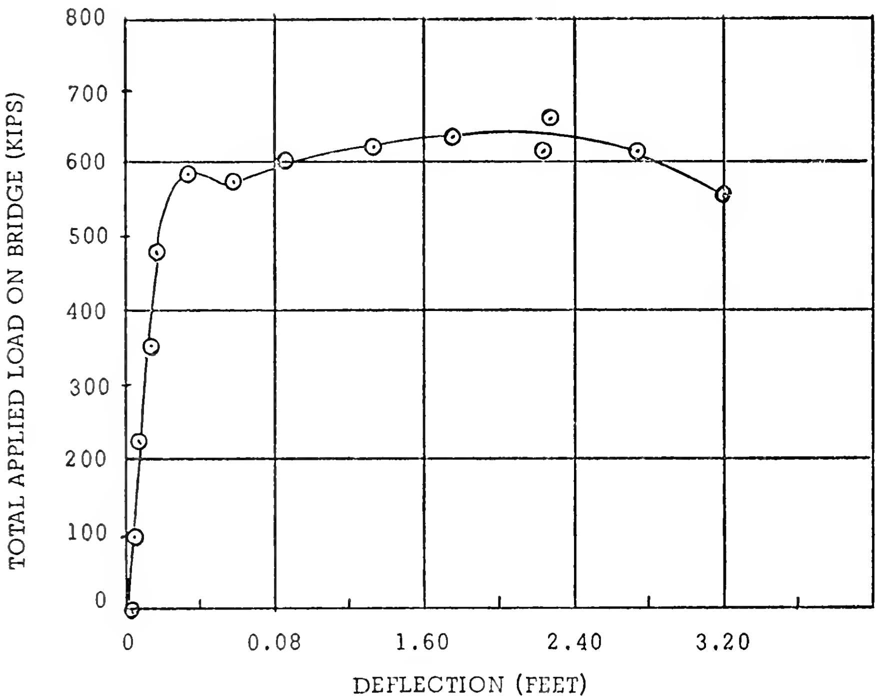


FIGURE 9. LOAD-DEFLECTION CURVE FOR BRIDGE 4

Bridge 3. This bridge, designed in 1937 for the equivalent of an H-15 loading, had the highest capacity of any of the four tested. It behaved elastically up to very high loads, and it was not obvious when yielding first occurred. The reason for the absence of a clearly defined yield load is related to the stress-strain curve for the steel, which indicated a very short yield plateau followed by sharply increasing stress in the strain-hardening region. Yielding did not occur simultaneously in all steel bars in all members at a cross-section. The strain in the most highly stressed bars would increase to the strain-hardening region while other bars were reaching yield. This continuing process resulted in the behavior illustrated in Fig. 8.

Bridge 4. The load-deflection curve for this bridge (Fig. 9) closely resembles that for a typical intermediate-grade structural steel, which is not surprising in view of the fact that the bridge was a non-composite steel girder type. However, the stiffness of the bridge up to yield was considerably greater than that predicted for a non-composite bridge, because a high degree of composite action existed up to yield.

Failure of the bridge was initiated by yielding at the section of maximum positive moment. After this occurrence there followed considerable rotation of the resulting plastic hinge and very large deflections with only a nominal increase in

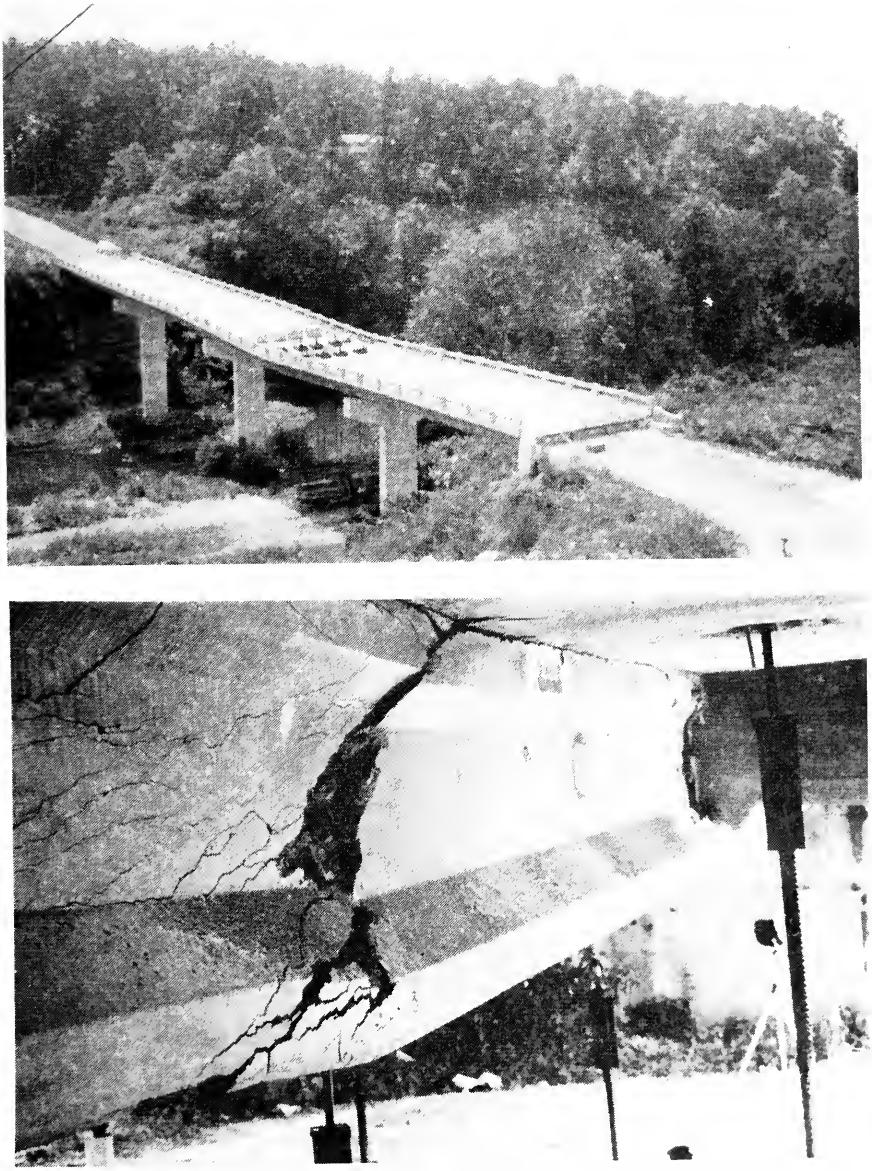


Fig. 10—Photographs illustrating mode of failure of Bridge 1 (above) and Bridge 2 (below).

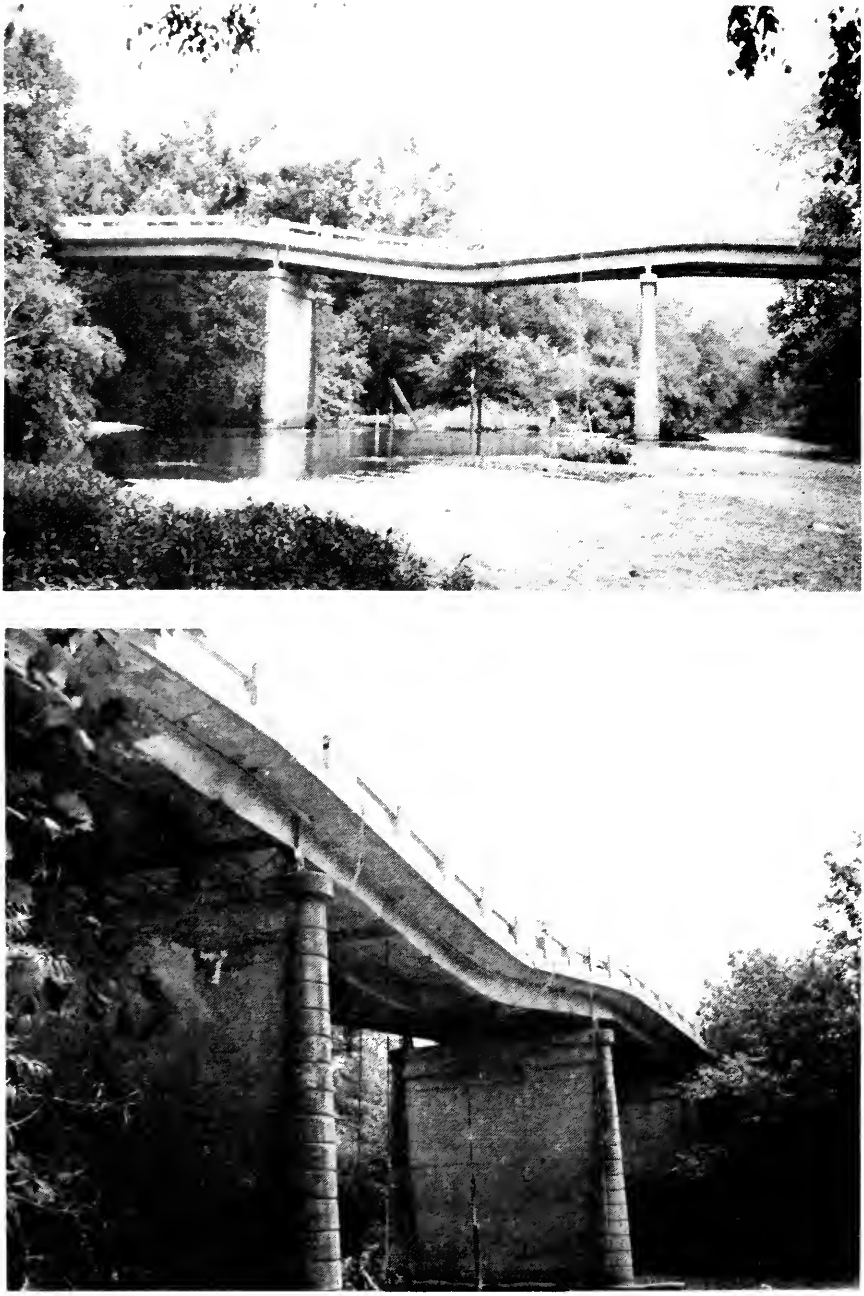


Fig. 11—Photographs illustrating mode of failure of Bridge 4.

load. Finally, plastic hinges formed near the two piers on the sides away from the loaded center span, and futher deflection took place with a reduction in load capacity.

Ultimate Loads

The ultimate loads obtained from the field tests are tabulated as follows, along with the center line deflection at ultimate load.

Bridge Number	*Ultimate Load (kips)*	*Center Line Deflection at Ultimate Load (inches)*
1	1250	22.8
2	1140	9.5
3	1580	7.2
4	640	26.4

COMPARISON OF MEASURED AND CALCULATED ULTIMATE LOADS

The ultimate capacity of each of the four bridges was computed by two methods, each method making use of the stress-strain relationships for the steel and the ultimate compressive strengths of the concrete obtained from laboratory tests. The first method, referred to as the "theoretical method," used strain compatibility relationships to calculate the ultimate moments. This method is described in detail in Reference 7. Also, for the two continuous bridges, Bridges 1 and 4, redistribution of moment was considered in a "limit analysis."

The second method, referred to as the "AASHO Method," makes use of the basic assumptions described in the 1971 and 1972 Interim Specifications of AASHO[8,9]. This method is described in detail in Reference 2. No account was taken of longitudinal redistribution of moment, and "ultimate" loads were taken as those which produced ultimate moment at the most highly stressed cross-section.

A comparison of calculated and measured ultimate loads is given in Table II. It may be observed from this table that the "theoretical" values are relatively "close" to the measured values, while the "AASHO" values are in all cases lower than measured. There are two primary reasons for the AASHO values being low:

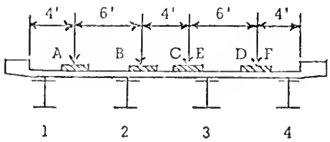
TABLE II

COMPARISON OF MEASURED AND COMPUTED ULTIMATE LOAD

Bridge Number	Measured Ultimate Load (kips)	Computed Ultimate Load (kips)	
		Theoretical	AASHO
1	1250	1270	930
2	1140	1267	1100
3	1580	1465	844
4	640	696	388

TABLE III

LOAD DISTRIBUTION COEFFICIENTS - BRIDGE 4
STATIC LOAD TESTS



Load Location	Load At Each Point (kips)	Total Load On Bridge (kips)	Ratio of Bending Moment (%) 1	2	3	4
A, B,	28	56	38	34	22	6
A, B,	59	118	37	34	22	7
C, D, E, F	28	112	7	20	34	39
C, D, E, F	59	236	7	21	36	36
A, B, C, D	28	112	22	28	29	21
A, B, C, D	59	236	22	28	29	21
All	16	96	20	28	24	28
All	28	168	19	29	26	26
All	38	228	20	28	26	26
All	49	294	20	28	26	26
All	59	354	21	28	25	26

NOTE: Load points E and F are 14 feet away from the line ABCD.

(1) The yield strength of the steel was used in the calculations as the upper limit of steel stress, with no account taken of strain-hardening; (2) no consideration was given to longitudinal redistribution of moment in continuous Bridges 1 and 4. However, it is the opinion of the writers that the "AASHO Method" is a reasonable approach to the calculation of bridge capacity, and they submit that the results given in Table II support the argument that this method gives a "reasonable lower bound" to actual bridge capacity.

Comments on Lateral Distribution of Load

The test results relating to lateral distribution of load are described and analyzed in detail in Reference 1. The primary contribution of these tests was to show that lateral distribution coefficients remained essentially constant from working load up to first yield of the steel. This fact is illustrated in Table III, which lists percentages of longitudinal bending moment taken by each girder for increasing magnitudes of applied loads.

Conclusions

The most significant findings of this research effort can be summarized in three subject groupings as follows:

(1) *Dynamic Behavior*

The rolling-load data indicate that the lateral distribution of load depends mainly on the lateral position of the load on the bridge and that the superposition of results from tests with single vehicles compared favorably with the results of tests with two vehicles on the bridge simultaneously. Conclusions relative to the effect of speed on the impact of the bridge were not justified.

(2) *Lateral Distribution of Load*

The results of these tests provide little really "new" information with regard to lateral distribution factors. They do tell us that these factors don't change appreciably as loads are increased all the way to first yield of the steel. And this is useful information, particularly in light of the increased use of "Load Factor" design.

(3) *Ultimate Strength*

There were two particularly interesting facts which emerged from the failure tests. First, even though the load to the supporting girders might be unevenly distributed at first yield of the steel, the loads generally were redistributed such that *all* girders reached their full flexural capacity before failure. Second, a conservative lower bound to this total bridge capacity can be calculated rather simply by use of the principles underlying the load factor design method described in the 1971 and 1972 Interim Specifications of AASHO.

ACKNOWLEDGEMENTS

Appreciation is expressed to the Tennessee Department of Transportation, Bureau of Highways for their considerable help in the conducting of the research described in this paper. In particular, the writers wish to thank Henry W. Derthick, Tennessee bridge engineer, for his continued interest and helpful suggestions. Also, special thanks are due Robert F. Varney and the Federal Highway Administration for their valuable support.

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The Railroad Research Information Service— What It Is and How It May Be Used

74–643–6

By J. H. SEAMON
Manager, Railroad Research Information Service
National Research Council

We can expect to see dynamic changes in railroading in the final three decades of this century. Research, planning, and the systems approach will play an increasingly larger role in railroading.

We wish to introduce you to the Railroad Research Information Service, which we call RRIS. RRIS is being developed within the Division of Engineering of the National Research Council by the Highway Research Board. The Railroad Research Information Service is located in the Joseph Henry Building in Washington, D. C. RRIS is funded by the Federal Railroad Administration of the U. S. Department of Transportation.

The scope of RRIS includes information on the planning, building, maintenance, and operation of rail transportation systems. Two types of information are stored in the RRIS File: summaries of ongoing and recently completed projects, and abstracts of reports and articles that are within the RRIS scope.

The information sources for RRIS are those organizations that produce railroad research information. These sources may be grouped generally into five groups:

- Railroads
- The railroad supply industry
- Universities
- Institutes and firms
- Government agencies

RRIS is a unit of the Transportation Research Information System, which we call TRIS. TRIS includes several information services:

Note: Discussion open until October 15, 1973.

• Highway Research Information Service	HRIS
• Maritime Research Information Service	MRIS
• Transportation Noise Research Information Service	TNRIS
• Railroad Research Information Service	RRIS
• Related (Safety)	

The information for all of the TRIS information services is maintained on a magnetic tape file. Computer processing of TRIS information is handled by the National Academy of Sciences' IBM 370/135 computer system.

Some indication of the potential usefulness of RRIS can be inferred from the experiences of other TRIS services:

- There are over 46,000 entries in the HRIS file after seven years.
- There are over 4,000 entries in the MRIS file after three years.
- There are over 3,000 entries in the TNRIS file after three years.

After one year of development of RRIS, there are over 2,500 entries in the RRIS File. RRIS is off to a good start because the FRA provided over 2,000 abstracts to RRIS.

Entries to the RRIS File are classified according to the RRIS Subject Areas of the RRIS Classification Scheme, and the entries are indexed with appropriate Subject Terms. The Subject Areas group entries into broad categories, while the Subject Terms identify more specific subject interests. Track and Structures, for example, is a Subject Area, while Rail and Welded Rail are Subject Terms. Retrieval of information from the RRIS File can be according to selected Subject Areas or selected Subject Terms.

RRIS services include: File Searches (either manual or computer) on request; Current Awareness—an automatic, periodic output of new material added to the File; and Publications.

The RRIS Bulletin will be a regular publication, and special publications will be issued as the occasion requires.

The RRIS Fee Schedules reflect the basic non-profit nature of the National Research Council and the support of the Federal Railroad Administration. File Searches and Current Awareness Outputs will be performed at cost. (At the present time, based on the size of the RRIS File, the cost will be approximately $35 for computer time plus a per-page-of-output charge for printer time.) The first several RRIS Publications will be free to Qualified Requesters while the supply lasts. In the future, a nominal charge will be made for RRIS Publications. (To help cover printing and distribution costs.)

We have stated previously that sources of RRIS information include:

- Government Agencies
- Universities
- Institutes and Firms
- Railroads
- The Railroad Supply Industry

It has been our experience that reports produced by railroads and by the supply industry are less generally available than reports produced by the other sources, so RRIS will make a special effort to obtain reports from railroads and from the supply industry. RRIS will encourage professional persons associated with railroading to make their work available to the entire railroad community. One way to accom-

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		6. Period Covered (321A6)
7. Authors (331A3)		
8. Performing Organization Name and Address (312A3)		9. Type of Report (321A5)
		10. Contract or Grant No. (452A5)
11. Sponsoring Agency Name and Address (431A3)		12. No. of Pages (322A2)
		13. No. of References (322A6)
14. Supplementary Notes (751A2)		
15. Abstract (711A2)		
16. Subject Terms (621A3)	17. Availability Statement (341A3)	

TRIS Form R1 Nov. 72

R & D PROJECT SUMMARY

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		3. RRIS Subject Category (551A3)
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		6. Title and Telephone No. (422A2)
7. Sponsoring Organization Name and Address (431A3)		8. Responsible Individual (441A3)
		9. Title and Telephone No. (442A2)
10. Activity Status (451A2)	11. Activity Level (131A6)	12. Contract or Grant No. (452A5)
13. Start Date (451A6)	14. Completion Date (451A7)	15. Type of Funding (452A4)
16. Total $ (452A3)	17. FY73 $ (462A5)	18. FY74 $ Estimate (462A6)
19. Objectives, Scope, & Method (721A2)		
20. Subject Terms (621A3)	21. Title, Author and Date of Reports Issued (811A2)	

TRIS Form R2 Nov. 72

plish this objective is to make their work available to RRIS. We are interested in both Ongoing Work and Completed Work.

To facilitate entry of Ongoing Work to RRIS, we have developed TRIS Form R2, the R & D Project Summary Form. This form provides on one page the spaces for all information required by RRIS. Instructions for completing the form are printed on the reverse side of the form. We will be pleased to supply these forms to anyone who wishes to provide project information to RRIS.

To facilitate entry of Completed Work to RRIS, we have developed TRIS Form RI, the Technical Report Data Form. This form provides on one page the spaces for all information required by RRIS. Instructions for completing the form are printed on the reverse side of the form. We will be pleased to supply these forms to anyone who wishes to provide reports to RRIS. For completed work, RRIS needs to obtain one copy of the actual report.

We would like to suggest that TRIS Form RI, the Technical Report Data Form, (or an equivalent form) be used as the first page of a report. This practice will provide complete information about the report in one convenient place. U. S. Department of Transportation practice is to use a form of this type for the first page of reports. The TRIS Forms were based on the DOT form.

Selection of material for entry to the RRIS File is based on:

- RRIS Selection Criteria.
- Availability of the source document (original report) to the railroad user community.

RRIS Selection Criteria include:

- Interest in the particular subject
- Timeliness of the material
- The information value of the material
- The value to the railroad user community
- News items generally are not selected for RRIS

RRIS general practice is to require an availability statement for every document entered to the RRIS File. Such a source document (original report) should be available to: qualified requesters—members of the railroad user community—for a reasonable length of time, free or at a reasonable charge.

Photocopies, microfilm, or microfiche are acceptable when copies of the original report are no longer available. (Good practice is to avoid colors in the original report.)

Some internal (company) reports may contain confidential or proprietary information. RRIS will not reference such material.

We would like to suggest that many internal (company) reports can be made available to RRIS and the railroad user community by: placing the confidential or proprietary data in an Appendix; making the report available to RRIS and to the railroad user community without the Appendix.

We generally prefer for the author of a report to write an abstract of the report, because: the author is more aware of the importance of the material; this practice will save work for RRIS.

However, RRIS will accept reports without abstracts, in which case we will write the abstracts.

Generally, promotional literature is not entered to the RRIS File. However, promotional literature can be entered to the RRIS File when such literature meets the RRIS Selection Criteria and Availability Requirement.

The scope of RRIS includes railroad rapid transit. Specifically, RRIS coverage for rapid transit includes:

- Railcars
- Power
- Signals
- Track
- Operations
- Communications

But RRIS does not plan to cover the sociological aspects nor the urban economic aspects of rapid transit. Bus related transit will not be covered.

Transit Research Information, both railroad and non-railroad, is available from TRIS. Non-railroad Transit Research Information is covered by HRIS. A Transit Research Information Brochure is available from HRIS.

RRIS welcomes feedback from the user community. Tell us how we can help you. If you have used our service, tell us if we helped you or if we did not help you.

You can help RRIS. Tell other railroad community people about RRIS. Get your name on the RRIS mailing list and encourage others to do so. Suggest to RRIS what type of coverage would be most helpful for you.

What does RRIS really mean to the railroad community in terms of a service? When RRIS is fully operational, and with cooperation in obtaining input material, the most important railroad research information will be available quickly and in convenient format, which will significantly reduce the time required for a literature search, and help avoid duplication of research effort. The RRIS goal is to provide complete, useful information on railroad research from one convenient source.

RRIS provides a new and important feature to the railroad community. Formal publication of reports in established journals is no longer the only means of making research work available to the railroad community at large. The ability of RRIS to reference internal reports, provided the company is willing, means that a much greater amount of research information is now available to the railroad community.

RRIS has reached agreements with certain foreign sources to permit entry of selected foreign railroad research information to the RRIS File. It is expected that agreements will be reached in the future to permit more extensive entry of foreign railroad research information to the RRIS File.

Have We Been "Railroaded" by Education?

74–643–7

By DR. BRUCE M. DAVIDSON
Academic Dean
U.S. Naval Academy

Have we been "Railroaded" by Education? Without taking a vote, but judging by your age—and mine—I'd say we would be inclined to give a disgruntled "You Bet" to that.

Just look at the headlines!—Kent State—Wisconsin—Berkeley—Columbia.

And if you think that's bad, just look at the students!

The Superintendent of Schools for the District of Columbia, Dr. Hugh Scott, recently told me, "I wore jeans because my family couldn't afford anything else. Nobody wants to work for anything! I can't even tell the boys from the girls—the faculty from the students!"

It seems that there isn't even loyalty for our country, much less for the company one works for.

And the "younger generation"? They're a bunch of immoral ingrates! Why bother with them?

You know, it doesn't take much to develop a very negative attitude about the education of the younger generation. In fact, you can easily develop a protective shell that would preclude your evaluation of any college educated youngster regarding employment with your company. And we haven't even mentioned his academic ability (or lack of it) as a factor.

Let's first see what happened. Then, let's examine what the real graduate engineer is like, and, lastly, let's see what that translates into as a course of action, because like Death and Taxes, you face evolution as inevitable. You need to know how the environment has changed in order to live in it!

Let me go back to the good old days—when you and I struggled to finance our way through school. Most of us think of an engineering degree as encompassing 145–155 semester credits of engineering oriented courses. I can ever remember my classmate chewing tobacco because smoking wasn't allowed in the drafting room!

What happened to those good old days?

First, educators noted that high schools got all charged up about SPUTNIK and presumed that this produced students at an advanced level. So colleges got rid of a lot of courses that were offered in the freshman year. Their assumption was false. Modern Math doesn't really prepare the *engineering* student for anything more than more modern Math! He doesn't learn Math as a valuable tool of the profession—just as a *gadget.*

Then there were some Pied Pipers who came along with a lyrical flute and seductive words about Humanities and Social Studies (had to bring sex into this). Educators promptly cut out a number of "how-to-do" course work and injected a semester or more of this Cultural Mystique. (I would be the first to admit that the spitoon in the drafting room would now be called an ecological hazard, but no less of one than the styrofoam cup from which ecologists drink coffee while decrying the plight of the world).

Note: Discussion open until October 15, 1973.

At this point in the transformation we have "advanced" the education program by expecting high schools to do what colleges and universities did a generation ago and we have substituted a cultural experience for "know-how" courses. Some of the best "cultural experiences" I ever had were during a summer I spent on a construction job and not in a Soc class.

The next tremor that shook the foundation was the reduction in credits required. Almost like a gas price war, institution after institution cut the credit requirements to remain competitive. We were told that engineering was no longer competitive with the science degrees and we weren't getting our fair share.

I got news for you. When engineering required one extra course per semester over what math and science majors took, we weren't competing. We never intended to compete. Engineers need to be motivated and willing to work and gain experience through doing. When they desiccated the engineering degree it became competitive for a different student—the less motivated theorist who didn't want to roll up his sleeves. I say that this was the Trojan Horse of education because many of the schools who first "discovered" this fictitious competition were those who had abandoned the idea that engineering was a practicing profession. They viewed it as a science. Dr. Muller, president of Johns Hopkins, recently made a very honest evaluation of their undergraduate program. He stated that their undergraduate programs are not structured to prepare a student for a job or a profession—it was an education. Most schools are that candid. Their faculties are science-oriented and can't teach applied concepts of engineering. Many of their staff never held a job other than in education. It was this group of Mahatmas who claimed to have "vision" and reduced the average semester credit load to approximately 15 from the traditional 18 credits. (We at the Academy still hold to 18).

In this one great execution they eliminated from their curricula many of the courses they were no longer competent to teach—drawing or graphics, technical report writing, economic analysis, labs, timber design, even courses that were in a few short years to regain favor—sanitary engineering—which has now been canonized and renamed environmental science.

With what have these two shocking changes left us? A reduction of 30% in the last 6 years of the percentage of students enrolling in engineering programs, and a degree program in engineering that at best will include a year to a year and a half of professionally oriented courses and with many staffs hardly able to teach that. No wonder you hear a thundering cry that threatens to split the engineering educators asunder. They are calling for the return of professionalism to engineering; not to the cook-book concept of 30 years ago, but *to the modern, up-to-date, concepts of applied engineering.* Such programs will provide those industries who depend upon professional engineers, not pseudo-scientists, with the kind of talent they need. Unfortunately, it appears that to obtain this goal it will require a fifth year to prepare the student professionally by putting back in a Master's Program that which was cut out of a four-year program in the last two decades.

Let me now turn to a second major change that has occurred which I'm not sure is completely separable from the first. In fact, the liberalization of the engineering program has probably reinforced the cancer of the second. Have you any idea of what the current attitudes are of students who are graduating? Oh, you have a son! Well, do you know what the rest of them think?

From the "Graduate Magazine 1972" a survey reported the following:

When asked what would you like to do upon graduation,

(1) Only 25% really wanted to go out and begin a career.
(2) Almost 25% thought they ought to go on to Grad School.
Doesn't that tell you something? How many of us felt we had to get more education following the undergraduate degree? Either Dad's hit an El Dorado or the present undergrad programs short-change the student. Some educators market their product like Arthur Murray Dance Salons.
(3) 25% wanted to travel or do nothing.
(4) 16% were totally in a quandry or wanted to "create."

When that same group was asked what do you think you'll *have* to do when you get out

(1) 21% figured they'd go to work on a career.
(2) 22% would have to take a job to make a living.
(3) 21% would go on to grad school.
(4) 14% would travel or do nothing.
(5) 10% still were in that quandry.

What's all this mean?

(1) 6% of the students who wanted to relax would get a job.
(2) 18% of the students would take a job to make a living although it wasn't their wish.
(3) 4% who wanted to start a career didn't think they'd find a job.

Approximately 25% of the work force really doesn't give a damn about working but they have to eat.

One further question on goals indicated that 15% of the group expected to be in what you and I might construe as non-productive efforts 5 years after graduation.

Well, I haven't told you anything you didn't suspect but at least you have some statistical data to confirm your suspicions.

Now I suppose I'd classify you as "disenchanted" and convinced education has "railroaded" us—Welcome to the crowd!

Recent studies by Louis Harris certainly reflect the increasing skepticism of the public for education and the other "Establishment" groups.

Since 1966 Respect for the Supreme Court has dwindled from 51 to 19%. Respect for the Executive Branch has dwindled from 41 to 19%. Respect for the Military has dwindled from 62 to 24%. Even respect for the Business Leaders has dwindled from 55 to 27%.

In the last six years there has been an erosion of from one-half to two-thirds of the previous support of the "Establishment." No wonder this is the "Land of Disenchantment."

I frequently hear from industry:
Why recruit?
Who needs that ilk?
I wouldn't hire a creep!
All they want is to complain!
They're all ecologists!
or What I really need to hire is:

A. a design man
B. a traffic man
C. a manager
D. a decision maker
E. someone who gets things done
F. someone who can get us out of trouble
G. someone who can keep us out of trouble

Gentlemen, before knowing how to cope with life we have to understand ourselves—We've had the Shock Treatment!

What you need—as the marines say—is a few good men—*AND WOMEN!* (My daughter is a sophomore in engineering at Duke and loves engineering).

1. I think you need to be selective—examine the institutions that are educating the product you need. Not every institution has bought the science-oriented engineering program. Support those schools that have your kind of engineer. Determine what you want to hire and take measure of the institutions.

2. You need to select from those schools a few good men, recognizing that in today's world they may not earn that 20-year company pin. Let me speak to that as we are experts in this matter. We are one of four institutions who have an interest in the product we turn out—because we *are* the consumer! I've got seven constituencies to try to accommodate: Midshipmen, their parents, their Congressmen, the Faculty, the Alumni, the Fleet, and Admiral Rickover. You might think the Academy would try to achieve 100% retention in the Navy. Not on your life! That would mean we would keep the good—and the bad; the motivated—and the unmotivated; the managers—and the mismanagers. If we ever got 100% retention, we'd be decadent. It would mean that our best people couldn't compete with their civilian counterparts. No one would pirate them away. Actually, we weed out the worst and we lose some of the best. I think that 2/3 retention after 10 years' service is a good investment for the Navy. Some of our top flight men who leave still make significant contributions to society. I should think about 50% retention in a railroad company would be satisfactory because whereas the Navy can't entice and exchange personnel with its competitors (we have no exchange program with the Russian Navy), you can. You can encourage engineers to maintain a career in railroad industry without remaining with your company. It may even be a blessing for both organizations and the individuals.

3. I believe that what you need to do, and I suggest you make a major effort in this area, is to examine the graduates from accredited technical institutes. These young men and women are given excellent education in the "hands-on" engineering techniques. They are sharp young people who can pull their weight. They are characterized by an attitude of expectancy that they will have to produce. They are motivated—they want to work—and they want to get ahead. Some of them could have coped with the university education *if* it could have met *their* objectives. Here is a reservoir of talent that could help the railroad industry strike out once again and recapture the imagination and romanticism of young America. And let's face it—many of the jobs you have don't need university-educated engineers. The Engineers' Council for Professional Development has accredited over 80 institutions with programs leading to degrees in engineering technology. Check these programs out. Perhaps develop specific degree programs to meet your needs.

I was impressed recently with the SMU Annual Report where they point out that the work force in agriculture has dropped from 20% to 5% of the total work force in the last 40 years: the productive life time of a college graduate. We are beginning to see a drop in the work force associated with "industry" while that part of the economy identified as "service" has increased from 40 to 60% of the total work force in 30 years. Educators need to think about this and direct their efforts to preparing young people for careers of the future—not of the past. Likewise, the railroad industry, as a consumer of educated talent, needs to shuck its mantle as an industry of the past. Unless you do, you will not be a part of the future in the minds of the younger generation.

Railroads need to give serious consideration to backing community colleges as a source of talent. You should do just as ASCE did a few years ago in backing institutions in the construction management field. Perhaps you need to select five institutions that might develop programs of value which would provide two-year technicians for the railroad industry. Guarantee the students summer employment (not driving spikes either) and a job upon completion of the program. You wouldn't necessarily have to raise $10,000/annum/Inst. as ASCE did; for in this day and age faith and a progressive image are things Money Can't Buy, and assurance of a job upon graduation is an attractive incentive.

This is what we in the Navy have done, only we put it all in one school at a cost of more than $10,000 per man but it pays off. We have admission standards equal to Purdue. We have a four-year attrition rate of about one-third of the class and that includes voluntary resignations, separations for conduct as well as academic separations. That is significantly lower than any engineering college I know. And we're accredited. The young men who take our program know it's a challenge. We expect a great deal from them and they expect a great deal from us in the form of an education.

Now you can't afford to go as far as the Navy in its selection and support of students in order to induce them to choose a career in "Our Industry" but you must not become a victim of the syndrome of disenchantment, the anti-education-establishment hate that can be so easily rationalized.

Neither can you afford to sit idly by and wait for educational institutions to produce graduates from various programs in hopes they'll meet your needs.

Yes, the times have changed! We let Mids have cars as seniors.

Yes, the attitudes of students have changed—Mids don't know if they want the Navy as a lifetime career.

Yes, the priorities of life have changed—some Mids prefer law to the bridge.

Yes, institutional education has changed—if it's practical it's suspect!

But one thing hasn't changed! The railroad industry still needs engineers.

Like the Marines—YOU NEED A FEW GOOD ENGINEERS AND THEY'RE THERE SO GO GET 'EM TIGER.

A National Data System for Grade Crossing Safety

74–643–8

By OTTO F. SONEFELD
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Federal Railroad Administration

I am very pleased to lead off this presentation of the National Grade Crossing Inventory and Numbering Project (GCINP). As you may imagine, a very high degree of cooperation is required on this type of project, and it is imperative that all the participants know as many of the details as possible. Since this audience contains most of the main actors, I am sure this will be one of our most important presentations.

As any of us become involved in any given project, we sometimes lose sight of the reason we became involved in the first place. My role today is to discuss the reasons we are involved in this project and explain why we consider it to be so highly important. I speak not only as a representative of the Department of Transportation, but as a member of a broad-based team working toward a common goal.

First of all, most of industry and most public agencies have hopefully passed the point where major decisions are made by the seat of the pants. Indeed, the most successful organizations are those which act from a strong and well-analyzed information base. And that is precisely what the GCINP is all about. We are talking about tools which allow money to be spent on a basis that insures the best possible return on the dollar—whether that dollar is from the public treasury or the railroad corporate budget.

Two of these tools provide the foundation upon which the system must be built: (1) inventory data that is accurate, complete and current, and (2) accident data that is also complete, accurate and current. A third tool is the unique identifying number at each crossing which permits pulling all the data together.

As you know, the Federal Railroad and Federal Highway Administrations, with assistance from the highway departments and railroads, did submit to the Congress a report which identifies the magnitude of the grade crossing problem nationwide, and recommended a program level necessary to protect crossings over the next ten-year period. Now I want to assure you that a tremendous amount of analysis and considerable expense went into that report. Nevertheless, the analysis was based of necessity on expended sample data reported in rather broad categories. While this information was adequate for recommendations on broad policy issues on a national level, it was not in sufficient detail to allow good evaluations of state-by-state needs. In a critique of the report to Congress, presented at the 1972 National Conference on Rail–Highway Safety at Ohio State University, it was stated: "The report ends without filling in many of the blanks that need filling before responsible authorities can design corrective measures. The scale of the data is by and large too big to permit state and local authorities to develop corrective programs, either on- or off-site."

This is true. We came face-to-face with the need for this current national project in preparing the report to Congress. We found that current available information did not even provide for an accurate measurement of the total number of public grade crossings in the United States. The two principal sources of this information

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(i.e., the ICC Reports and the FHWA State Highway Inventory) differed by approximately 10,000 public grade crossings nationally. When ICC statistics were compared with state highway department data, we found discrepancies in some states of 1000 or more crossings. The discrepancies in inventory data, and the impossibility of reconciling those differences, was the final straw in convincing us that there was a very real problem.

With regard to accident data, only one-third of the train-involved accidents are required to be reported to the FRA under the Accident Reports Act. We estimate that more than 12,000 accidents involving trains and highway vehicles occurred in 1970; the FRA statistics included approximately 4,000 of these accidents. Therefore, some 8,000 grade crossing accidents are not being properly assigned in national accident statistics. With the addition of the data related in these 8,000 accidents, it is reasonable to assume that the rail–highway accident problem would be better defined and much better understood. Public assistance (full or partial) would be better justified. The fact is that by focusing on the accident problem as 4,000 accidents annually, we are short changing ourselves in making a case for the importance of grade crossing safety!

The third tool—the placement and maintenance of a unique number at each crossing—is the key to successful utilization of this information system. This unique number will ensure that all parties involved in any exchange or analysis of data regarding a grade crossing are making reference to the same crossing, by simply referring to the number. As you know, there may be as many as five different parties involved in providing or using grade crossing data—the railroad company, the highway agency, the police authority, the public utility commission, and the Federal government.

Without each crossing being identified by its own unique number it is impossible to correlate accident history with individual grade crossings or classes of crossings. At the state level, many states maintain grade crossing accident reports in both the Public Utilities Commission (PUC) and Department of Public Safety (DPS). In most states these cannot be associated with specific crossings. In very few states is it possible to correlate the police and railroad reports. At the Federal level, it also is not possible to associate those accidents with specific crossings.

Without this capability to correlate accident data with inventory data on a site-specific basis, no one is really in a position to determine accident costs or define the causal factors related to crossing accidents with any credibility. On the other hand, the ability to correlate inventory and accident data would permit the type of analysis necessary to zero in on both the causes and costs of accidents. In view of the problem just recited, it seemed safe to conclude that grade crossing information systems at the national, state and railroad level are badly fragmented and incomplete for development of comprehensive planning and program purposes. Faced with this problem, it was necessary to decide just what course of action should be taken.

One alternative was to do nothing; that is, rely on the individual states to conduct and maintain inventories as in the past. As noted, however, this technique has not been totally successful in the past and with all the other highway safety needs, it didn't seem likely that we would get a complete inventory via this route in the near future. After much consideration among all the involved parties it was concluded that the most efficient and effective way of developing and maintaining a comprehensive information system—and the way to get it now—was to ask each railroad to make a site-specific inventory of each crossing on its lines. Railroad employees have the experience and access to company records necessary to provide information, on a systematic basis, through review of company records or by on-site inspections, or a combination of both. For those items which the railroads could not be expected to have available, such as highway traffic data, the highway departments will provide the input.

In the area of accident reporting, we are currently considering a few different alternatives. These include leaving the system just as it is now; expand it to include all accidents, with possibly less data required for each accident; or place added emphasis on obtaining data from police reports. It is very possible that the existing T-sheet will remain the same as it is now until we have had time to integrate that data with the inventory form to see what information really is essential.

In order to carry out this program, the Federal Railroad Administration contracted with the Association of American Railroads for the inventory, numbering and project management. The individual carriers through the AAR will share the cost of the program on a 50% rail industry, 50% DOT basis.

Technical requirements and procedures to insure successful completion of the project are being coordinated through an AAR steering committee and a technical advisory committee consisting of representatives of four DOT agencies, the state highway departments, and the public utility commissions.

When the project is completed next winter, inventory data will be made available to individual railroads, state highway departments, and local agencies. In return, we plan to arrange with these agencies to supply updated data into the system on a periodic basis.

At the state and railroad level, this computerized data base will permit a program of crossing improvements based on priorities that assure the most mileage out of the limited funds available for these purposes. At the national level, it will permit evaluation of grade crossings programs within large but well defined classes. At all levels, it should prove to be the heart of an information system that will produce analyses, innovations, programs, and developments that you and I consider impossible today.

You know, both the president of the AAR and the Federal Railroad Administrator have hailed this project as an excellent example of private industry cooperating with the Federal government in an effort to improve safety. To that I can only add that this is not only an exercise in cooperation but a unique opportunity to lay the groundwork for a system that will provide benefits to all concerned for many generations to come.

The Impact of Current Legislation on the Railroads

74–643–9

By JAMES R. COXEY
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Environmental Studies Division, Research and Test Department,
Association of American Railroads

Let me talk to you briefly this afternoon about the impact of current (environmental) legislation on the railroads. The actual enactment of laws is not really what needs to concern us; our concern necessarily goes to the implementation of the legislation. That is, what is going to be required of the railroads in fulfilling the intent expressed by the Congress in enacted legislation, and even more specifically, what the railroads have to do to be found in compliance and not in violation of the regulations that define how the intent of the legislation shall be accomplished.

It is immensely gratifying that the fits and starts that characterized the implementation of the Clean Air Act of 1963 and the Federal Water Control Act of 1956 resulted in learning that has been applied in the form of the Clean Air Act Amendments of 1970 (which really was a 1971 Act since it wasn't signed into Law until December 31, 1970), and the Federal Water Pollution Control Act Amendments of 1972 that was signed into Law on October 18, 1972. Both have provided much guidance for how to go about implementing the brand new Noise Control Act of 1972 signed into Law on October 27, 1972.

From the Clean Air Act and the Water Control Act it became very clear that to enact an environmental law intended to reflect the wishes of the people was one thing, and to define means for carrying it out was quite another. Among the things that were made clear was the need for a theretofore non-existent Federal agency whose sole job it would be to define how to accomplish the intent of the Congress. This resulted in the creation of the Environmental Protection Agency that has grown from zero employees to over 10,000 employees in less than three years. Since most of the subjects covered by environmental legislation require knowledge of a highly specialized nature, it is hardly surprising that there weren't anywhere nearly enough experts in the many fields covered who were available for attachment to the Environmental Protection Agency, and for this reason it is hardly surprising that regulations were often developed by people who didn't know enough about what they were doing and knew it. This certainly has not been the wish of the Environmental Protection Agency but rather it was a natural consequence of not enough specialists to go around, frequently coupled with a hostility on the part of industry and a native distrust of government that resulted in a reluctance on the part of industry to share with the EPA knowledge that there is no way for the government to ever have in a measure equal to that which industry must have constantly at its fingertips to be able to run its affairs.

To resolve these problems the EPA has adopted a practice that is being reflected right now in the implementation of the Noise Control Act in which the EPA has formed a Task Force of its own members, other government agencies, and respected consultants to provide them with guidance in formulating their regulations. This provides in an orderly way for the first time for specialized, expert input available only in industry and government agencies specialized in a particular

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field, and should result in the best regulations that we, as a society, can develop consistent with the state of the art, the accomplishments that can reasonably be expected in the near and far future, and consistent with the costs of accomplishing the goals. There is much reason to believe that the Noise Regulations will reflect a new degree of reality in industry–government relations.

To be very specific, the EPA has created a Task Force chaired by one of its own people and comprised of thoroughly knowledgeable and competent consultants from within and outside government who will ultimately recommend what the regulations should be. The EPA has designated the National Bureau of Standards to develop and evaluate all technical matters that relate to the regulations being developed. The National Bureau of Standards, in turn, has appointed a committee from within its ranks augmented by outside consulting experts, and has invited the railroad industry to supply two members to that committee. This means that not only will the Task Force be assured that the National Bureau of Standards' recommendations to them will include the results of the many splendid noise studies that various railroads have made, but it guarantees that those studies will receive the attention that the railroads think they should have because the railroad members on the NBS committee will help determine what is transmitted to the Task Force. I can't imagine a system in which everybody's wishes could be more democratically expressed than in this system. What will happen to the Task Force's recommendations after it leaves their hands and goes to the Administrator for enactment has not yet been tested because this is a "maiden voyage," but it seems highly unlikely that the Administrator would fail to take the recommendations of his deputy when the deputy's position so obviously reflects the work of the best talent available in America.

The action of the railroads has been superb in providing to the National Bureau of Standards and the Environmental Protection Agency those studies that have been conducted on the railroads, and it has been a matter of great pride to be able to show those agencies that the railroads are doing this freely and without editing a single item out of their reports, thus, obviously assuring no concealment of pertinent data; this has gone a long way toward establishing the railroads as responsible organizations committed to the wishes of society and to the development of laws to best serve their needs.

The implementation of the Federal Water Control Act Amendments of 1972 is taking much the same form. The EPA executive responsible for developing effluent guidelines for the railroad industry came to the Association of American Railroads, openly stated what he would need to know, and asked the help of the Research and Test Department to provide that information. Again, ever sensitive to the absolute need to be credible, we did not try to get him to accept answers that we had available and could have given him in the comfort of an office, but instead we asked five railroads to serve as hosts to the EPA executive on their railroad properties and to show him the best and the worst, as well as the largest and the smallest of all the operations that fall under his jurisdiction. He was given total access to the railroad properties. Not one railroad refused or even hesitated to serve in this capacity. The EPA man asked that certain information be furnished to him and this has been done, forwarding to him, again intact and without abridgment or editing, each report from the five railroads visited.

Unfortunately, this system can be given an opportunity to work in connection with only those laws where there is Federal preemption of local, regional, and state laws. How to establish this kind of rapport in the thousands upon thousands of communities which insist on having separate and distinct regulations, such as is the case with the Clean Air Act that does not enjoy Federal preemption, is a monster of monumental proportions. This is why we are actively seeking to have the Clean Air Act amended so that it too will provide Federal preemption, thus assuring laws that reflect expert opinion and uniformity in provisions. We had hoped to get such an amendment in the 92nd Congress and failed; our attempts will be reintroduced in the 93rd Congress and, although we are incurably optimistic, I would be less than honest if I didn't say that our chances of getting such an amendment during this session of Congress are doubtful.

There can be not the slightest doubt that many subjects should be legislated at state and local levels but we think that where railroads are concerned, air, water, and noise matters are Federal in scope.

Another matter of great importance to the railroads is action taken on December 27, 1972 by the Food and Drug Administration in the form of "Guidelines for the Treatment of Railroad Conveyance Wastes for En Route Disposal." These guidelines govern the use of discharge-type toilets. The Research and Test Department of the AAR is proud to have anticipated these guidelines, and by the time they were enacted, three toilets had been developed for railroad use that met the requirements.

The year 1972 also saw new and tough pesticides and herbicides laws passed and we are proud to have been instrumental in having railroad use removed from the ban on the herbicide 2, 4, 5-T that has been so effective in the control of weeds and brush.

In addition to the attention that will be required in the course of implementing the legislation that I have been talking about up to now, we can expect 1973 to require our increased attention to the control of fugitive dust from open cars in transit; to the control even to the point of elimination of roadside fires from incandescent sparks; to the cross tie and timber disposal problem that has resulted from not being allowed to burn these items; to the handling of radioactive wastes; and to the unsightliness that results from irresponsible people dumping wastes on railroad rights-of-way.

In a report dated January 1973 the programs and costs for environmental control on the railroads were set forth, railroad by railroad, in a survey representing 97% of the industry. Many of you have seen this report and others who would like to have it can obtain a free copy by asking us for one. If you would like to have copies of the air, water, noise and toilet legislation that we have talked about here today, ask us for those too.

In summary, then, the impact of current legislation on the railroads stacks up about like this:

1) The EPA can be expected to doggedly pursue their efforts in air quality improvement because it is in this area that they have worked the longest and acquired their greatest technical credibility; it is where their largest commitment in time and money has gone; it is where they can get the states to do their "dirty work" because there is no federal preemption, hence no direct Federal requirement for enforcement; so it is where they will continue to test and prove their authority. In view of this set of circumstances, the railroads and all industry can be expected to be "driven up the wall" in trying to answer all the local enforcement people who love their newly acquired authority. Remember too that this has resulted in

tens of thousands of new patronage jobs. The fact that railroads contribute less than ½% of the total air pollution will not dampen the zealousness of these people.

2) Much more sensible rules and regulations will come from the Noise Control legislation where there is Federal preemption. However, you can be sure that virtually every piece of equipment on the railroads today will have to be operated more quietly in the future than it is today. The degree to which it will have to be quieter will be decided during 1973; enforcement will start in 1974. So, if you don't know which equipment is making how much noise, you had better buy a noise meter and identify your problem areas. Remember too that although the present thrust of EPA activity in implementing the Noise Control Act is directed toward noise impacting beyond the railroad property line, the OSHA employee health and safety considerations will quickly follow. We contribute about 3% of the noise that is complained about.

3) Implementation of the Water Law will also be sensible because Federal preemption exists. Here we contribute so insignificant an amount of pollution mostly in the form of fuel oil spills and coolant dumping that it is hardly worth talking about, but there are some real offenders in other types of industry and we get caught in the law necessary to control them. Guidelines for Effluent Control will be issued in 1973 and rules may be promulgated but enforcement probably will not be actively under way until 1974. We will no longer be allowed to indiscriminately spill or dump fuel oil, coolants, wash water, tank car residual lading and other types of fluids either on the ground or into streams, and frequently not into municipal sewage systems where the chemical imbalance that would result would interfere with the bacteriological digestion of the system.

4) In the matter of pesticides and herbicides it is to be hoped that sense will prevail as a result of the forceful and dynamic position of the highly competent and outspoken Secretary of Agriculture who recently told the National Industrial Pollution Control Council that 50 million Americans are alive today that wouldn't be alive as a result of our use of poisons in agriculture. With Secretary Butz also having been named by President Nixon as his principal advisor on natural resources, there is cause to hope that the EPA will not be allowed to surrender us to the Japanese beetle and the gypsy moth.

In a subject as dynamic and fast-moving as environmental concern it is almost sacrilegious to try to give even an overview in as short a time as we have had together today, but before I totally wear out my welcome I will close by saying sincerely that I have been honored by your invitation to participate in your program and hope that our attack on environmental matters that I have reviewed here this afternoon meets with your concurrence of how we should be proceeding in this area that has required that we all take a closer look at ourselves than we perhaps ever have.

The Evolution of Control Systems in Retarder Yards

74–643–10

By P. J. DelVERNOIS
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It is a great pleasure to represent Committee 14—Yards and Terminals, and to review with you today, "The Evolution of Control Systems in Classification Yards."

In our presentation we will relate some of the history from which present classyards evolved, and we will discuss the evolution of the process control and management information functions in the classyard. Then, we will review where we are today in classyards.

Basically, the two functions being performed in modern classification yards are those of process control and management information—the same two functions being performed by automatic control systems everywhere.

These basic functions are not new to the digital computer controlled classification yard. They are the same functions performed on the first switching tracks and whose necessity created the classification yard. What has occurred over the years has been an evolutionary process of sophistication of methods, brought about by the necessity of moving cars to their destinations more rapidly, more safely, more efficiently, and more cheaply. Never has the adage "Necessity is the mother of invention", been as true as it has been in regards to the development of the classyard.

To better understand the nature of the functions which take place in a modern digital classification yard, it may help to know how the classyard itself evolved, what the various functions performed are, and how they became necessary.

Long before railroads existed, people contracted other people to move things from Point A to Point B by boat or horse-drawn vehicles. These common carrier transportation companies had to receive, store temporarily, classify by destination, and document or waybill the material at Point A. After departure, and arrival at Point B, they received the material, checked it against the waybill, stored it temporarily, and classified it for pick-up or local delivery. They performed the basic process control functions and management information functions. The early railroads also had to do these things. A road locomotive assembled his train of one to ten cars on siding(s) at A, and then departed for B. At B, he switched the cars and awaited orders to assemble the same or other cars for transport back to A. In effect, classifying is the process of taking an incoming train, sorting the cars according to their destinations, and making up new trains.

As railroad transportation grew, it developed the country. It expanded the flow of goods and people, and created towns and villages. Not only did the number of destinations increase, but the frequency and the length of trains increased. With this growth came the need to switch and control cars with local engines; road locomotives had their hands full moving cars from A to B. Thus, the first classification yard was born. These primitive terminals performed the switching or rout-

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ing functions. Routing is the assignment of a specific classification track to a car and the alignment of all switches in its path to that track.

Eventually, simple ladder track arrangements were devised by connecting at an angle several parallel classification tracks with switches to a single straight lead track (Fig. 1). Switch engines moved the string of cars back and forth on leads until cars were switched into desired classification tracks.

The number of classifications was limited to the number of tracks.

Here we see an example of route assignments (Fig. 2). By definition, moves along the ladder are normal or N moves, and moves into a classification track are reverse or R moves.

If Car A is routed to classification Track 1, as we can see under Route 1, the switches 6–1, 5–1, etc., are aligned as shown. If Car B is routed to Track 2, the switches are then aligned as shown under Route 2 and so forth for all the others. The track assignment is management information and switch alignment is process control—our two basic functions.

Flat switching yards were originated by improving ladder track arrangements (Fig. 3). These were improved by providing a receiving track with entrance from the main line, a caboose storage track, and a yard lead track.

This latter track provided a working space for the "back and forth" motion of the locomotive and the cars yet to be switched. Switches were manually positioned by switchmen to agree with management information furnished by conductors.

With increased productivity in process control areas, corresponding increases were made in traffic management areas. Waybill racks were introduced (Fig. 4). These wooden racks had a "pigeon hole" corresponding to each classification track. Waybills, matching actual freight cars, would be sorted and stacked in appropriate slots. A simple system, which became standard throughout yards. Before cars could be switched, movement or management information was developed.

In 1883, the Pennsylvania Railroad introduced the first "rider" operated hump (Fig. 5). By elevating the straight lead and switching portion of a flat yard, a hump was created. The switch engine now only had to shove the cars to the crest of the hump where they were uncoupled while in motion. They would then run by gravity down the lead and into selected classification tracks. Throughput was improved as engines no longer had to move cars back and forth on ladders.

Riders furnished car control. They rode cars from the summit and applied hand-operated brakes to stop the car after it was switched to the desired track. This was a dangerous job.

Switchmen continued to manually position switches until remotely controlled, electro-pneumatic switch machines were invented by George Westinghouse. They were first introduced in a flat switching yard in Altoona, Pa., in 1891.

Traffic studies in the early 20's showed that 75% of a freight car's time was spent in terminal areas, and 25% moving in trains or standing on customers sidings (Fig. 6). Immediately, the challenge was voiced, and continues to be voiced, to increase freight car utilization. Pressure was on the over 1,000 flat switching yards, rider humps, and many small ladder track switching arrangements located throughout the country.

It was evident to Vice President George Hannauer and Master Car Builder Earl Wilcox of the Indiana Harbor Belt Railroad, that a "breakthrough" was needed

—a breakthrough which would speed up the basic process control functions, improve safety, and reduce costs. The question was, how to remotely control car speeds, and perform the same braking function which was then accomplished manually by the car riders (Fig. 7)

If they could solve this problem, they could increase car throughput dramatically.

Using air cylinders and pistons, borrowed largely from standard car air brake equipment, they devised in 1923—50 years ago—the first practical set of stationary rail brakes to squeeze the passing car wheels.

The friction between the rail brakes and the car wheel rims opposed the turning of the wheels, providing retardation. Thus, the car retarder was born. The inventors turned their invention over to the signal suppliers. Here we see Hannauer and Wilcox standing on the first commercially produced car retarder (Fig. 8). The year is 1924 and the yard is Gibson Yard on the Indiana Harbor Belt. The breakthrough had been accomplished.

Car retarders permitted cars moving over the summit to be spaced more uniformly and closely, with increases in yard throughput (Fig. 9). Elimination of car riders promoted safety, particularly in winter when cars, ladders, hand-holds, and hand-brake wheels are often covered with snow and ice. If cars were on the hump, the retarders were always ready to perform their process control function. This invention was perfected and applied to four large rider operated yards in the short space of 20 months. Initial retarder applications were made at rider humps which were raised flat switching yards (Fig. 10). These layouts required many retarders from crest to classification track, and many control towers to remotely control the retarders and switches.

Continued pressure to break jams in terminals in the late 20's led to the master-group retarder design (Fig. 11). This design, with more powerful retarders, reduced the number of items to be controlled by the tower operators. Each group retarder fed one to ten classification tracks.

Early retarder yards had remote manual control of retarders and switches. Large yards might require three or four control towers to provide adequate car and switching control. The operator visually observed a car's speed prior to its entry into the retarder. He varied the applied pressure to reach a mentally determined release speed. This speed was determined by the operator's feelings as to the car's rollability, i.e., a good or bad roller, and the distance the car must travel. Humping lists generally would contain car initial and number, gross car weight, load or empty car information, type of lading, the car's destination, and classification tracks assigned to yard masters. As cars reached desired classification tracks, operators checked lines of information on lists. These lists were received by teletype.

Increased throughput necessitated a better flow of cars to and from the class-yards. Receiving yards were added to receive trains, and prepare them for humping by bleeding off train line air. Departure yards were added to assemble cars from classification tracks preparatory to making local deliveries, or makeup of new trains. With these yards in line, and or wrapped around the outside of classyards, depending on available property, a modern terminal was created.

Receiving trains, classifying cars, and train makeup and departure are the three main elements of a terminal (Fig. 12).

During the depression and World War II periods, railroads delayed the application of retarder hump yards. They experimented extensively with inductive voice communication systems to obtain better control of humping locomotives. Some 30 manually controlled hump yards were operating at this time.

After World War II, railroads turned again to retarder yards. To improve process control performance, relay automatic switching systems were introduced so that one operator at the crest could select car routes, and the retarder operator could devote his time to car control. Then, closed loop retarder speed control systems were developed. Car speed was measured by doppler radars operating in the "X" band (Fig. 13). Radar measured actual speed, along with an operator's feel as to the necessary requested exit speed from the retarder, are combined in a speed comparison system to form an error signal. This signal controlled the retarders. The operator now devoted more time to observing rollability of cars and distances to go.

But, operator judgments still left much to be desired; continued progress was necessary at classyards. By measuring a car's acceleration from two radar velocity measurements, over a measured distance, car rollability information was obtained in the 50's (Fig. 14). This information, along with car weight, automatic distance to go, grades, and route information, were combined in an empirical relationship to automatically determine the car's requested exit speed. Analog computers were ready for the process control functions of automatic routing and automatic car speed control, and installations were made on 30 yards.

The middle 60's saw the application of digital computers to the terminal area. What analog computers could do for process control digital computers could also do and more. It was only necessary to interface analog and digital signals to and from the computer. The advantage of the digital computer is memory at reduced cost. It was now economically feasible to keep an automatic inventory of cars as they were classified, and display this inventory on video display tubes. There is no need to make written lists. In short, automatic MIS had arrived.

To improve throughput over the hump, developments in the late 60's provided "on board" automatic speed control systems for hump locomotives (Fig. 15). Request speeds received by radio, are combined with actual speeds from axle tachometers to provide control commands for locomotive propulsion, brake, and emergency systems.

The necessity in some applications for further increases in throughput led to the design of yards with master, group, and tangent retarders (Fig. 16). With this arrangement, the master and group retarders are used to control spacing between cars, and the tangent retarders provide the final adjustment to car speed to suit the desired performance on the body tracks. Since higher average car speeds are used in the switching zones below the groups, the chances of catchup between cars is reduced, thereby permitting higher humping speeds.

In covering the evolution of control systems in classyards, we have tried to pick out most of the "highlights" for you today.

Undoubtedly, other things, not included, have come to your mind. The results of all of the methods conceived, whether described or not, can be summed up in the progress chart shown here (Fig. 17) covering 50 years of progress in classyards.

A total of 55 retarder yards with remote manual control were built in the first 27 years. Aided by analog technologies developed during the war years, 45 yards were built with both semi-automatic, and automatic controls during the next 13 years. With the advent of the digital computer, some 17 automatic yards, along with 10 semi-automatic yards, were added in the next 10 years. A grand total of 127 classification yards of varying degrees of process control and MIS built during the first 50 years (Fig. 18).

Of course, the real breakthrough that made this progress possible was the application of the first practical car retarder.

So at this point I'll turn the microphone and slide control button over to Al Dasburg who will discuss the evolution of car retarders in classification yards to help commemorate the 50th anniversary of the car retarder (see page 504).

[Following are reproductions of some of the slides presented by Mr. De-Ivernois].

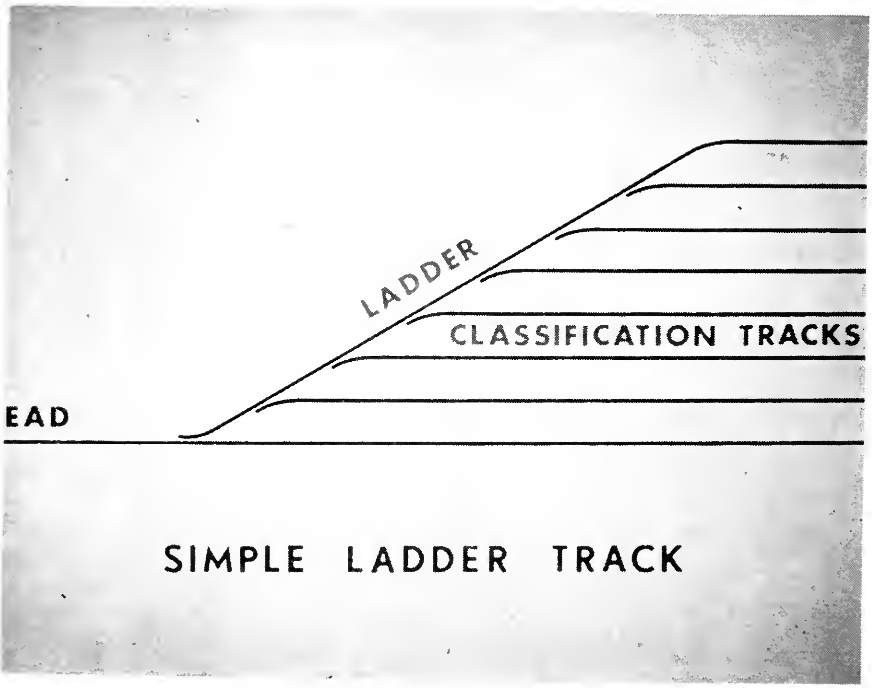


Fig. 1.

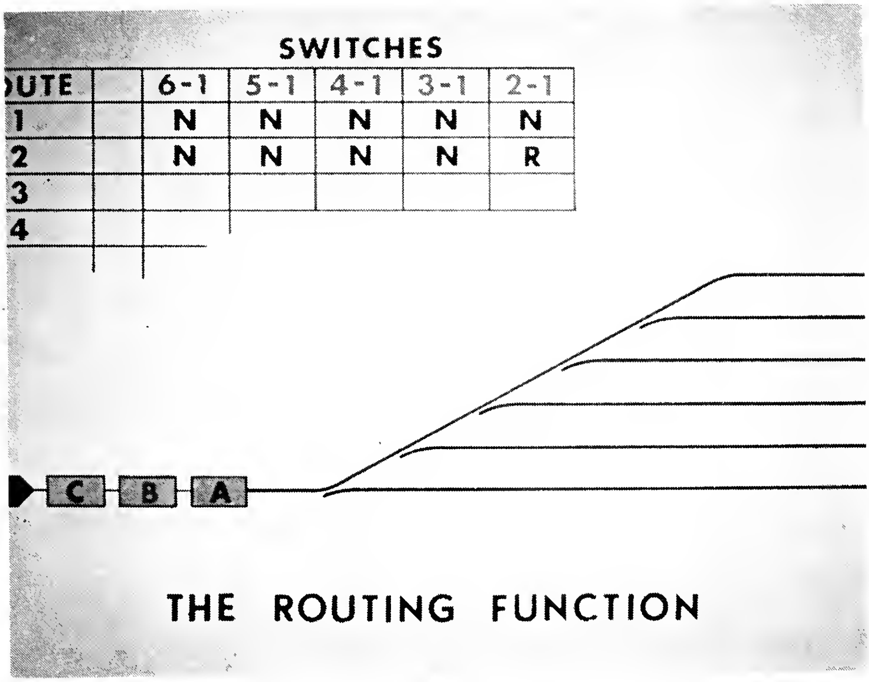

SWITCHES
6-1 5-1 4-1 3-1 2-1
1 N N N N N
2 N N N N R
3
4
C B A
THE ROUTING FUNCTION

Fig. 2.

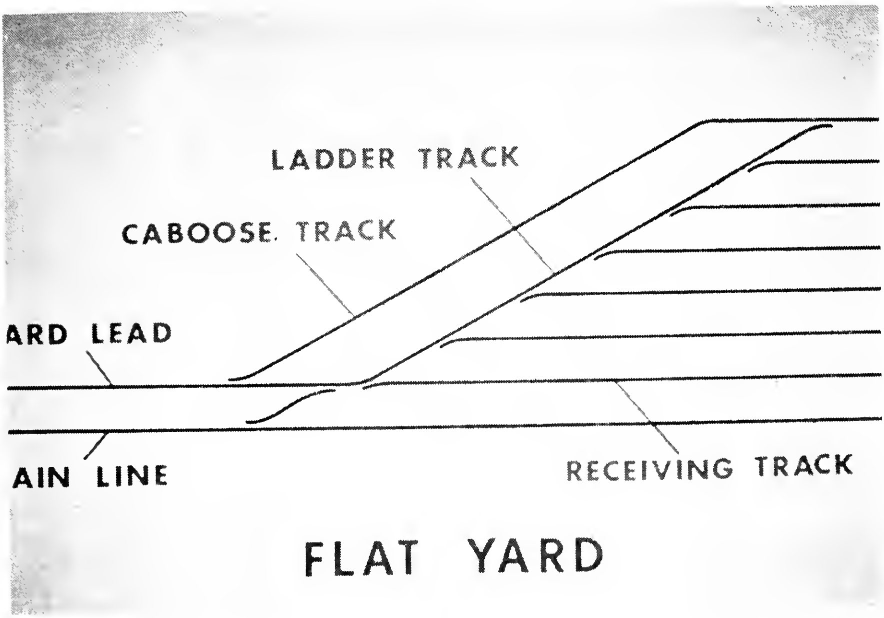

LADDER TRACK
CABOOSE TRACK
ARD LEAD
AIN LINE
RECEIVING TRACK
FLAT YARD

Fig. 3.

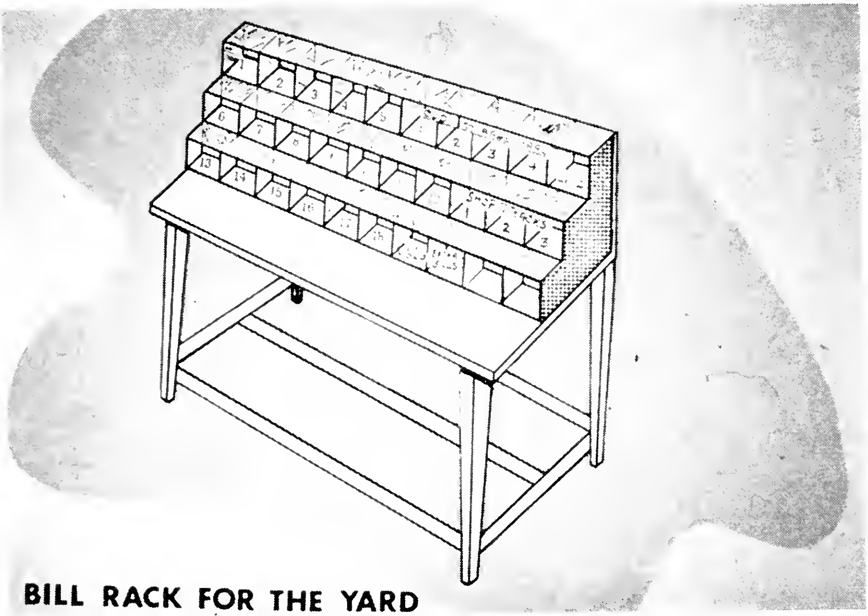

BILL RACK FOR THE YARD

Fig. 4.

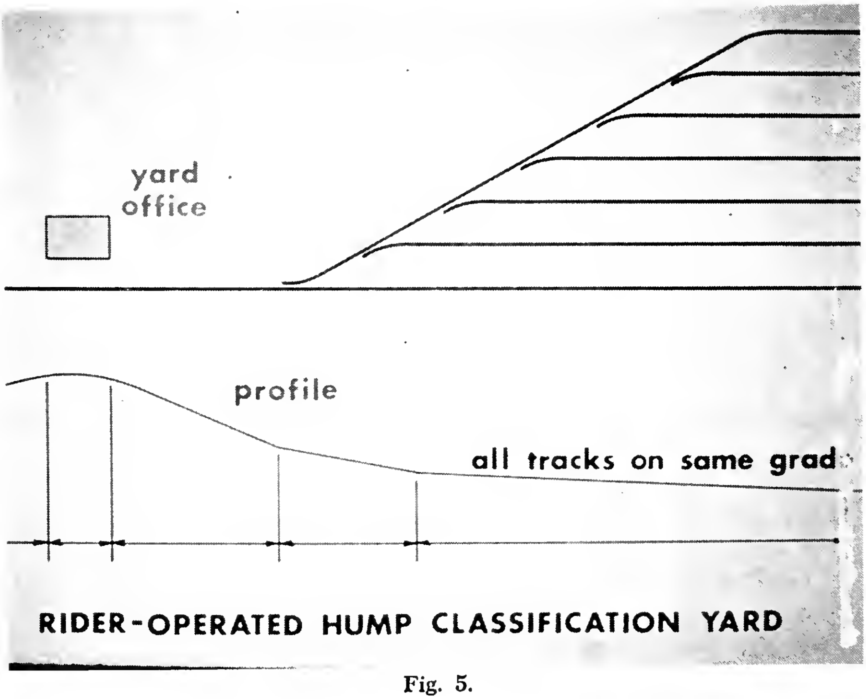

yard
office
profile
all tracks on same grad
RIDER-OPERATED HUMP CLASSIFICATION YARD

Fig. 5.

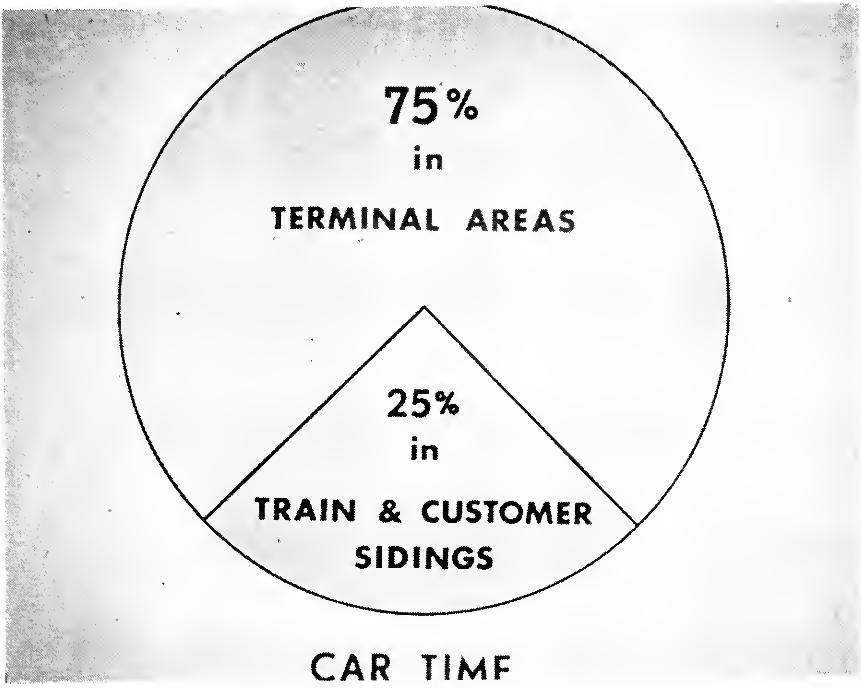


Fig. 6.

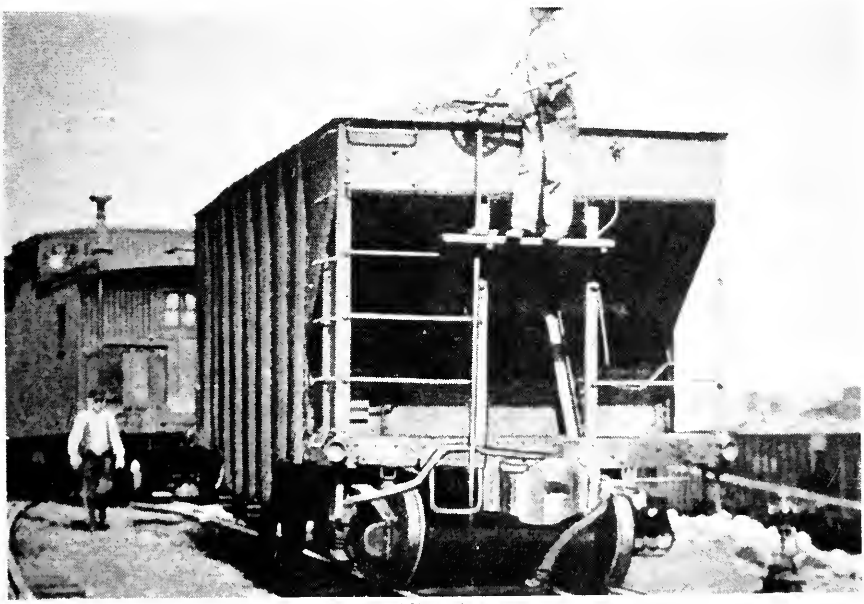


Fig. 7.

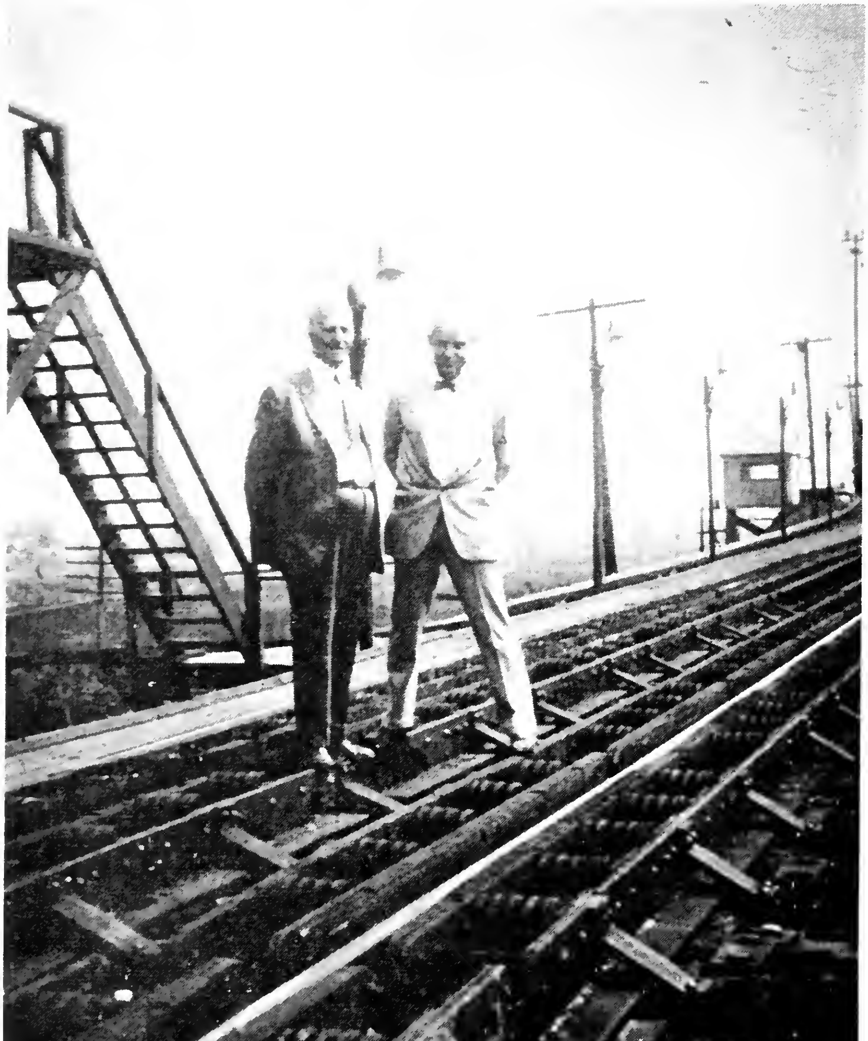


Fig. 8.

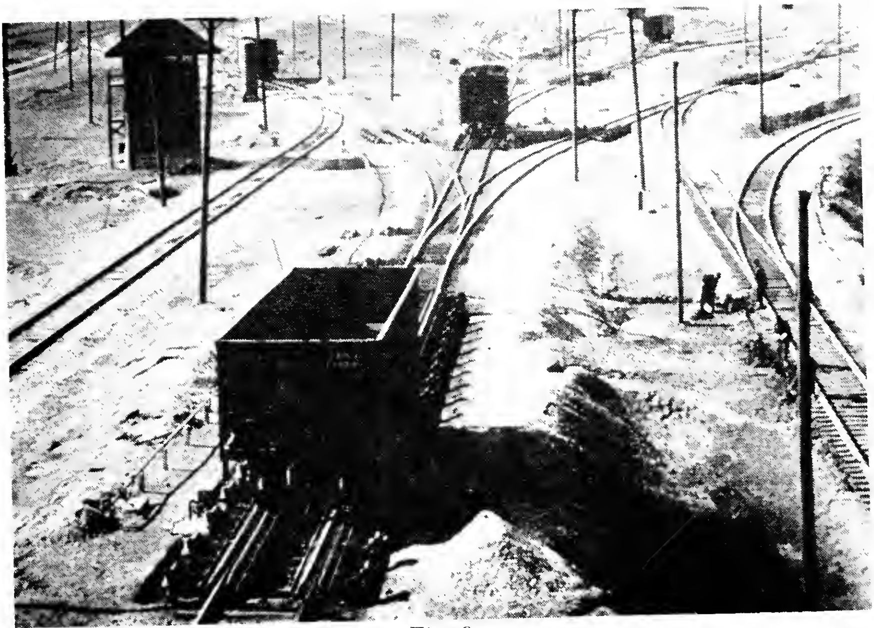


Fig. 9.

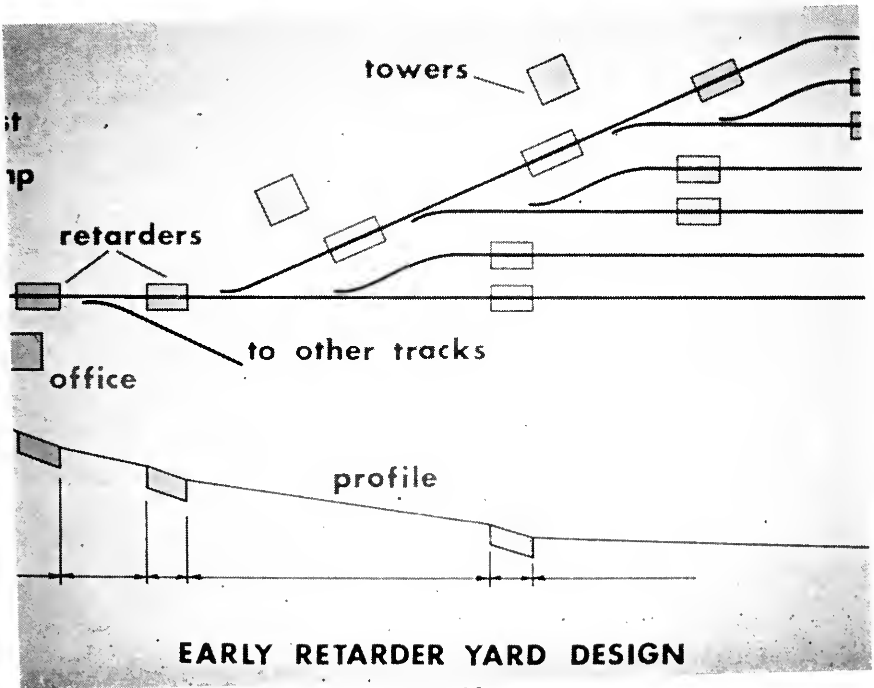

towers
retarders
to other tracks
office
profile
EARLY RETARDER YARD DESIGN

Fig. 10.

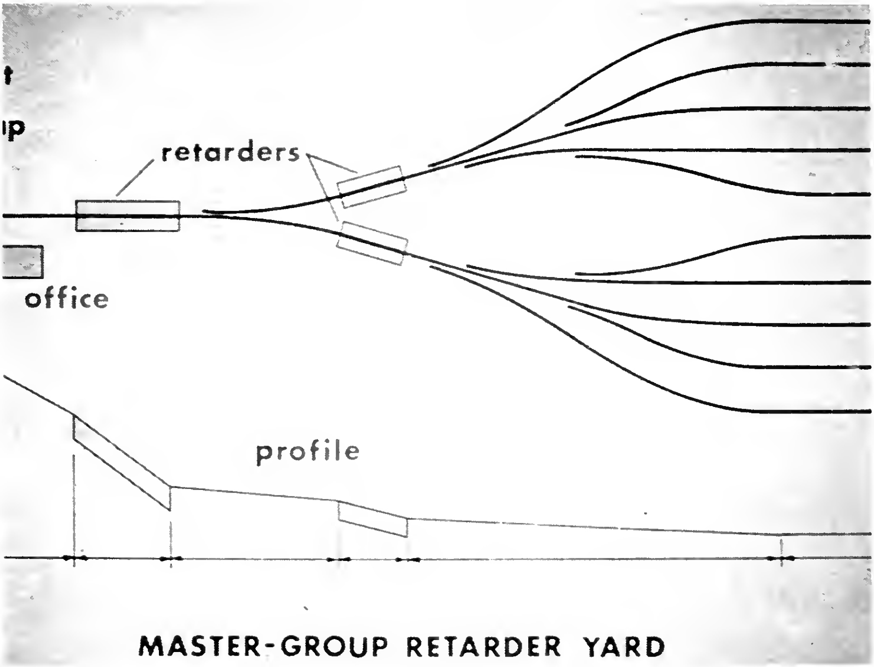

t
p
retarders
office
profile
MASTER-GROUP RETARDER YARD

Fig. 11.

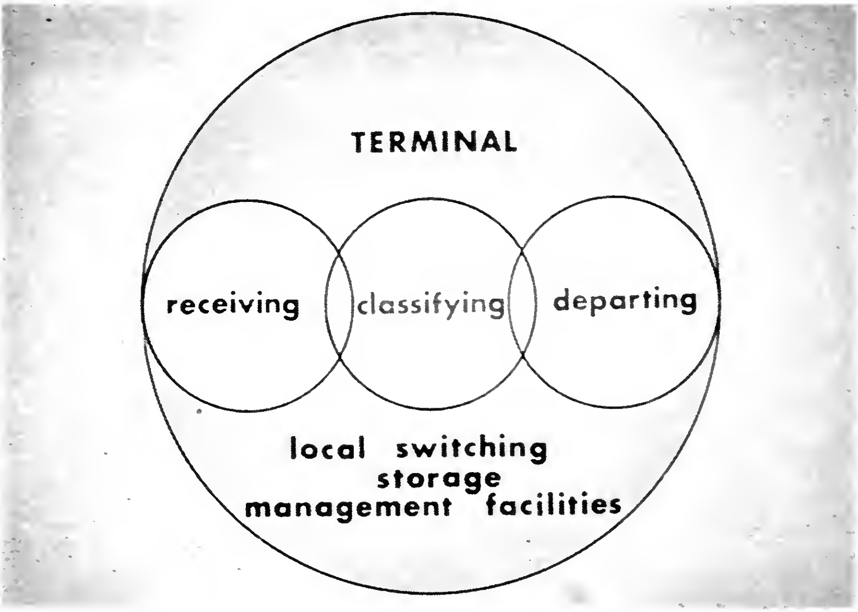

TERMINAL
receiving
classifying
departing
local switching
storage
management facilities

Fig. 12.

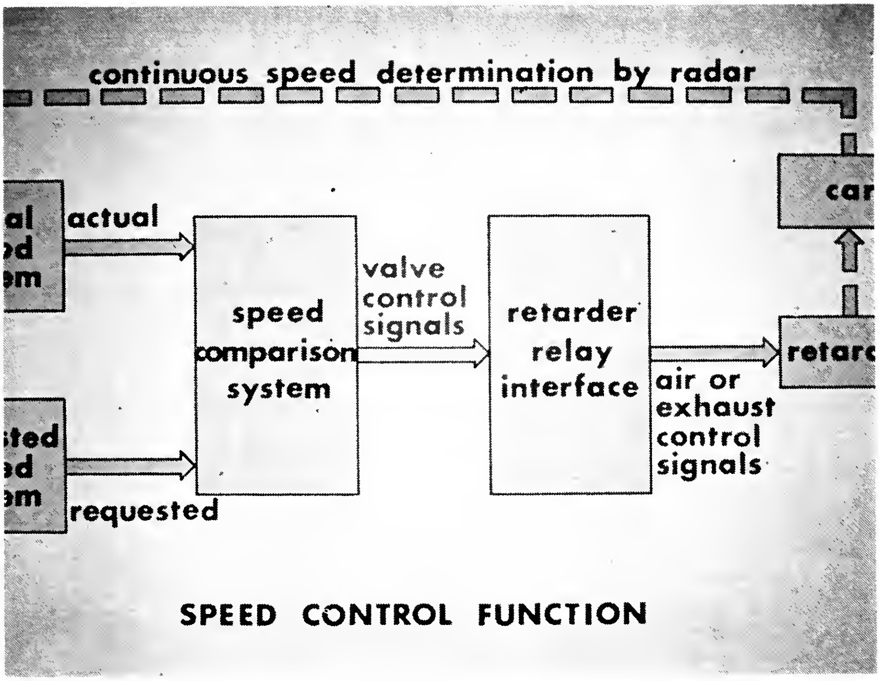

continuous speed determination by radar
actual
requested
speed comparison system
valve control signals
retarder relay interface
air or exhaust control signals
SPEED CONTROL FUNCTION

Fig. 13.

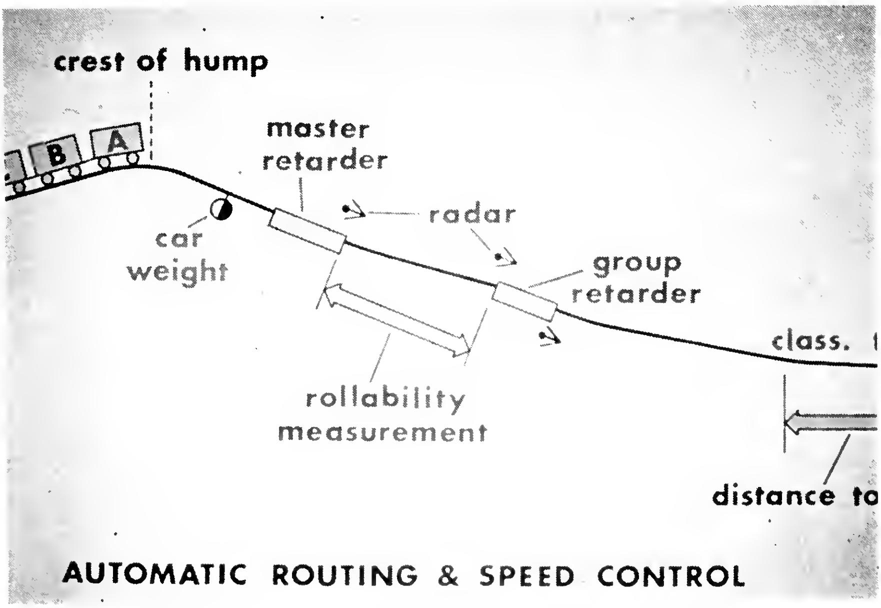

crest of hump
B
A
master retarder
car weight
radar
group retarder
rollability measurement
class.
AUTOMATIC ROUTING & SPEED CONTROL

Fig. 14.

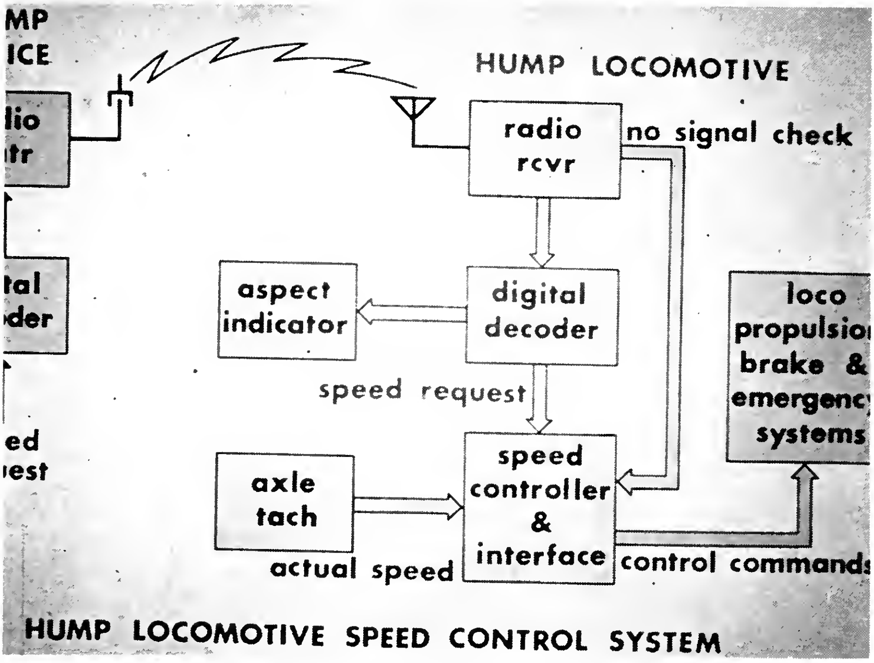

HUMP LOCOMOTIVE
radio
rcvr
no signal check
aspect
indicator
digital
decoder
loco
propulsion
brake &
emergency
systems
speed request
axle
tach
speed
controller
&
interface
actual speed
control commands
HUMP LOCOMOTIVE SPEED CONTROL SYSTEM

Fig. 15.

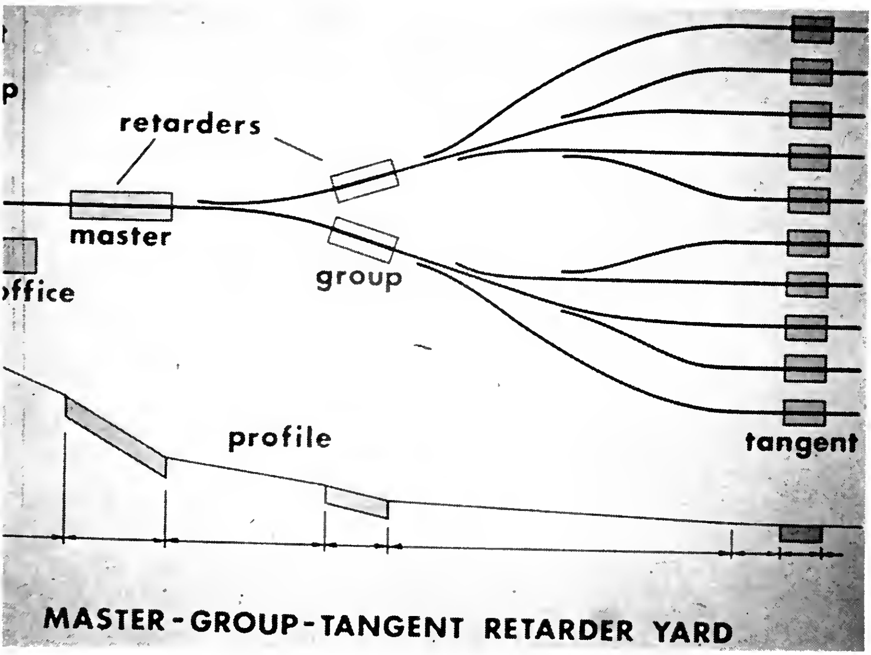

retarders
master
group
profile
tangent
MASTER-GROUP-TANGENT RETARDER YARD

Fig. 16.

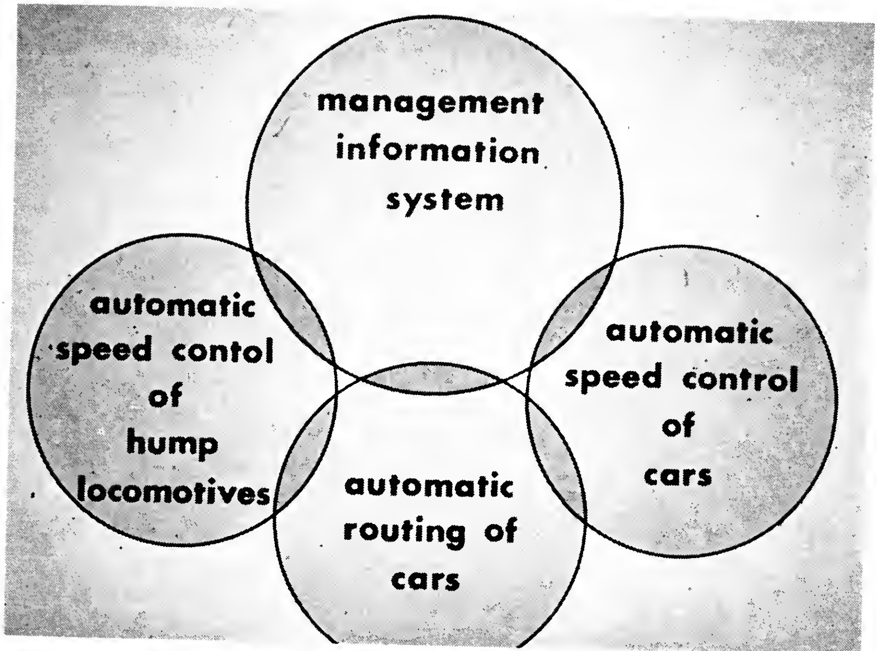

management information system
automatic speed contol of hump locomotives
automatic speed control of cars
automatic routing of cars

Fig. 17.

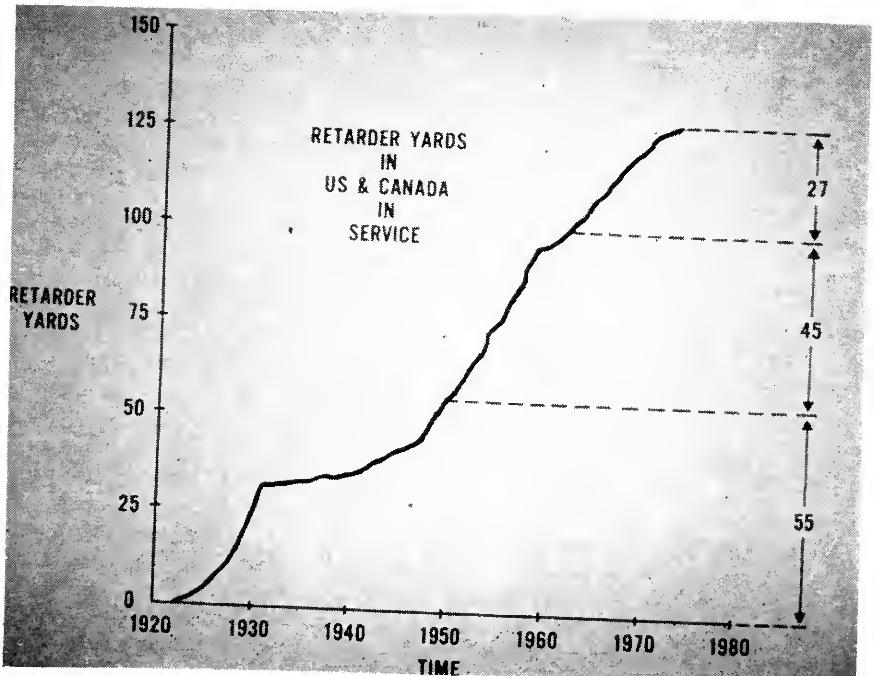

RETARDER YARDS IN US & CANADA IN SERVICE
RETARDER YARDS
TIME
150
125
100
75
50
25
0
1920
1930
1940
1950
1960
1970
1980
27
45
55

Fig. 18.

The 50th Anniversary of the Car Retarder

74–643–11

By A. V. DASBURG
Manager Customer Service
General Railway Signal Company

To help commemorate the 50th anniversary of the car retarder, we would like to discuss some of the factors involved in the retarder design evolution and cover most of the types of retarders which have been invented during this period, including their principles of operation.

The first practical car retarder invented in the U. S. was that put together by Mr. Hannauer and Mr. Wilcox of the Indiana Harbor Belt Railroad. The prototype was made from freight car brake rigging and controlled by an engine brake valve. The inventors licensed their patents to the signal companies for commercial sales and manufacturing.

Some of the factors in the retarder design evolution can be discussed under the following general headings; car wheel geometry, car support requirements, need for more powerful retarders, and modular construction.

Under Item 1, Car Wheel Geometry, among the first things to plague our early designers were variations in wheel diameters and widths and variations in their spacing on axles. These factors had to be coped with in order to balance the retarding forces on each wheel of each axle for a car passing through the retarder.

Another problem, car support, soon arose to challenge early designs because of the phenomenon of wheel squeeze-out, especially with light cars.

Since the brake shoes and supports were spring loaded, as soon as a wheel would squeeze out, the brake shoes would try to close together. This meant that the brake shoes and supports had to be rugged enough to carry the weight of the car. When "squeeze out" was seen by the tower operator, he would open the retarder to permit the wheels to drop back on the rails. This did not always occur. Therefore, flange guides were added to the lower ends of the retarders to accomplish that purpose.

Because of the ever-increasing weights of cars, which actually doubled in 40 years, larger wheel diameters and the changing yard designs, more powerful retarders became necessary—retarders which would remove more energy per foot of retarder length.

Brake shoe heights were pushed to the maximum allowable clearance limits. Brake shoe composition and hardness values were revised. Retarder components were made bigger and stronger, and retarder forces increased.

Another significant design influence was the need to reduce acquisition, installation and maintenance costs. This led to the unitized or modular construction of retarder levers, beams, controls, and the efficient distribution of retarder units in the yard layout.

Now let's take a brief look at the gamut of retarders which have been invented and the ways in which they operate. You will note that we have classified the types of retarders into A—Wheel clamping types, and B—Non-wheel clamping types. Under A we have retarders which are primarily powered electrically, electro-pneumatically, or hydraulically. We also have weight responsive types which are

Note: Discussion open until October 15, 1973.

powered by the car's own weight. Under B, the non-clamping types, we have the familiar skates, the ram, compression, spiral cam, and the electro-dynamic.

The wheel clamping type, which we will discuss first, is the one most universally used in the western Hemisphere. This is a diagram of its principle of operation (Fig. 1). When the shoes are clamped to the inner and outer surfaces of the car wheels, they provide a braking effort. Ideally, for maximum braking, we would like to clamp as high as possible on the wheel. The reason is that the force opposed to retardation is at the wheel center, therefore, the braking effect is proportional to the height (h) of the brake shoe divided by the wheel radius (r). This means that for a fixed value of (h) the braking factor decreases as wheel diameter increases.

Because of the necessity to provide clearance for the under carriage of the car, we can clamp only to a height which is a small portion of the wheel radius. We compensate for this limitation of braking effort by making the retarder longer and by increasing the pressure on the shoes.

This slide (Fig. 2) shows a picture of the first electrically powered retarder. The drive mechanisms are on the left.

Here we see an early electro-pneumatic retarder (Fig. 3) which operates in a manner similar to the electric retarder, except that the drive mechanism previously shown is driven by an air-operated cylinder and piston. Note that the springs are well protected.

Here we see the latest model of an electrically powered retarder (Fig. 4). The exposed springs of the earlier type have been relocated under the brake beams.

This (Fig. 5) is a diagram showing the principle of operation of these three retarders. On the left-hand side, a motor and drive mechanism or an air piston drives the throw rod. Varying the position of the throw rod varies the amount of retardation. The toggle lever translates this motion to the brake shoe levers. The brake shoe levers compress the spring and fix the position of the brake shoes. The function of the spring is two-fold; first, it provides an elastic element which compensates for variations in wheel widths, and second, by virtue of being compressed, it supplies the necessary clamping forces.

In an electro-pneumatic retarder, the springs have been replaced by air-operated cylinder and piston units at each pair of levers. The cylinders and levers are connected together to swing around a common lever fulcrum pin. Retardation is varied by varying the air pressure.

Now let's take a look at an inert, weight-responsive retarder, one where the car weight furnishes the retarding forces. It is installed at the lower end of a classification track as a skating retarder. Here, in view A (Fig. 6) we see the inert retarder in the normal position. Note that the brake shoe opening is adjusted to 5 inches. The narrowest wheel in use is 5¼ inches. In view B, when a wheel enters the retarder, it drives the brake shoes apart. Since the supports can not move outward, the only direction in which the unit is free to move is upward. The amount of lift is proportional to wheel width and independent of car weight. Once "lift off" occurs, in view C, car weight pushing downward produces retardation. This retardation force is directly proportional to car weight and independent of wheel widths. As long as the car is in the retarder, even if it stops, the retarder stays on. To provide a release feature for the inert weight responsive retarders, operable weight responsive units have been designed.

This is an example of such a retarder (Fig. 7). Note that rams are used to support the outside levers. Now let's see how it works. By adding view D to the inert principle of operation we see that by releasing the ram, represented by the right-hand support, we release the retarder.

We see here (Fig. 8) another version of this type of retarder which has operable pivots on both slides. The principle is shown in the next slide (Fig. 9). A double-acting hydraulic cylinder assembly raises or lowers the pivot points simultaneously on both the inside and outside of the retarder. These actions can be accomplished with or without car occupancy.

Now let's consider the non-clamping types of retarders. These are most commonly used in Europe. The familiar "skate" is set on top of the rail, either manually or remotely. After a wheel rolls onto the standing skate, the skate begins to slide along the rail. The weight of the car increases the friction between the sliding "skate" and the rail thereby producing retardation.

This is a view of hydraulic ram retarder units bolted to the gauge side of the rail (Fig. 10). If a car wheel flange traveling below a certain set speed engages the sliding cylinder, the unit will offer small resistance to the wheel as it is compressed by the flange. Above the set speed, which is adjustable, the unit will offer maximum resistance as it is compressed by the wheel flange. In effect, this is like rolling uphill, to produce retardation.

Below the set speed, as the cylinder is depressed, the oil flows through the metering holes somewhat as it does in the operation of a shock absorber. If the car speed exceeds the critical setting of the valve, the oil flow rate is sufficient to close the valve, producing retardation as the cylinder compresses. After the car wheel passes, the energy stored in the compressed nitrogen causes the cylinder to return to its original position.

The compression type of retarder is one which uses a length of compressible material instead of the conventional steel running rail. In addition to the energy absorbed during compression of the material, the car wheel effectively must roll uphill as it travels. The effect is a greatly increased car rolling resistance—thus retardation. Compression of the material is proportional to car weight. On the retarder shown here (Fig. 11) rubber is the compression material. The drawing how the rubber retardation is controlled. On the left, the rubber is being compressed by the car wheel. On the right, the rubber has been mechanically lowered to a point where the wheel flange is riding on a special plate and the rubber is not in position to be compressed. By remotely controlling the height of the compression material, car speed control can be obtained.

Here (Fig. 12) you can see to the right of the duct work a track-mounted spiral-cam type of retarder unit. The unit consists of a rotatable cylinder with a spiral cam along the outside, which acts on the engaging car wheel flange as shown in this slide. Rotation of the cylinder is resisted by internal hydraulics to provide programmable speed control. The unit can be retracted from the wheel flange engaging position by remote control.

The last unit we will discuss is the electro-dynamic retarder. This type of retarder has been around for a long while, the first one having been installed in England in 1930. The operating principle involved is based on an electro-dynamic effect that has been known for a long time also, the eddy current effect.

Magnetic flux is caused to flow by placing many turns of an energizing coil parallel to the running rails in a U-shaped steel body as shown on this drawing (Fig. 13).

The cross sectional views (Fig. 14) show two models, one with two energizing coils and one with a single energizing coil. For our present purposes, refer to the right-hand view. Current flow (1) in the windings of coil No. 1 in this view produces magnetic flux in the U-shaped section. This flux flows through the moveable braking bars (5), the wheel (6), then the braking bar (5) and returns to the U-shaped section (1). As the flux passes through and is cut by the moving wheel, eddy currents are created in the wheel. This produces a retardation in opposition to the direction of motion. By controlling the voltage applied to the energizing coil, the amount of retardation can be varied.

To summarize, then, what we have covered: There are two basic types of retarders, wheel clamping and non clamping. The wheel clamping types fall into two categories, primary powered and weight responsive. The non-clamping types have an even greater variety—skates, rams, compression, spiral cams and electro-dynamic. We have tried to cover 50 years of progress and invention in classification yards and retarders during a short period of time. Obviously our discussion on any single element had to be brief.

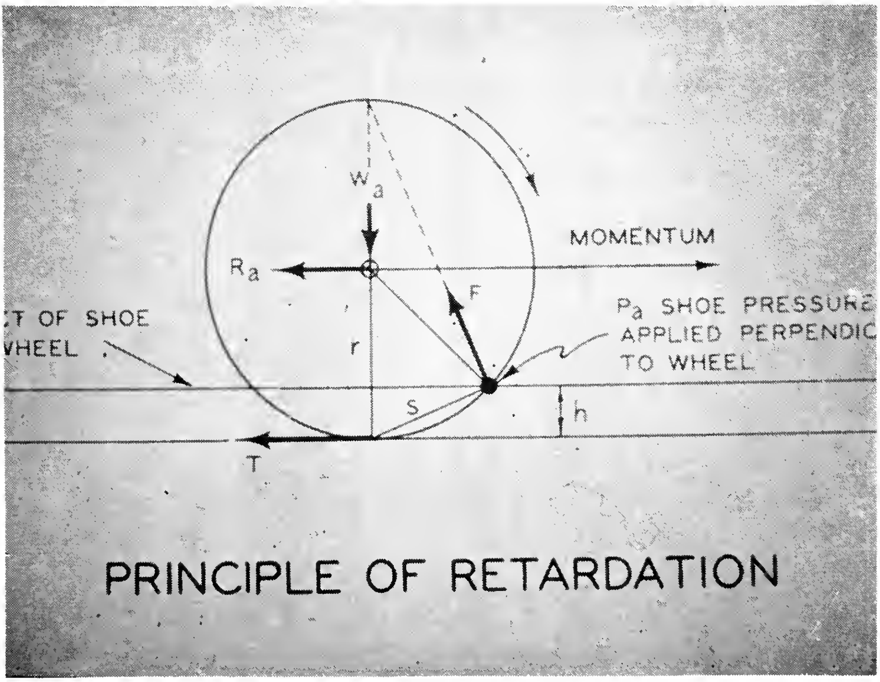


Fig. 1.

Fig. 2.

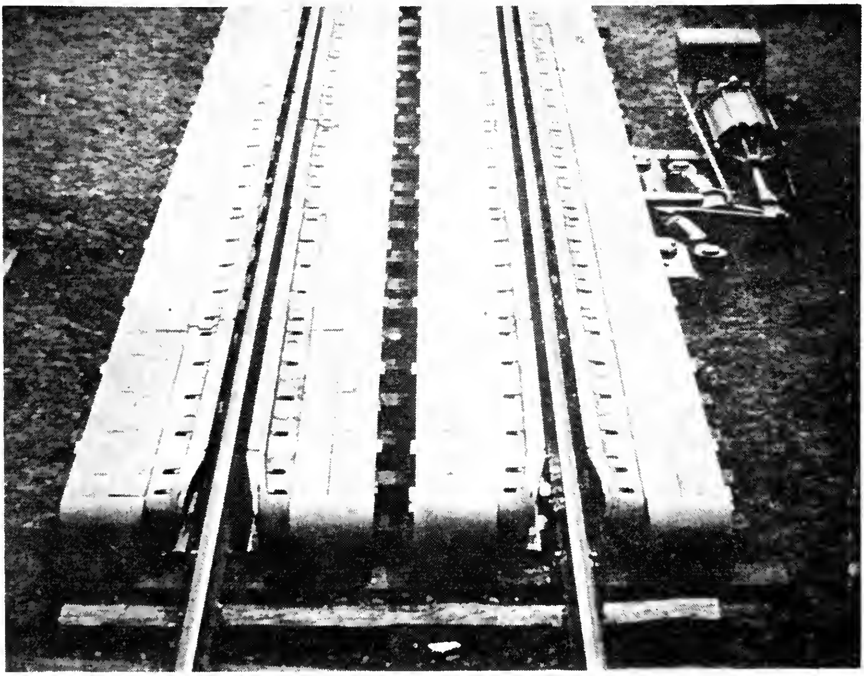


Fig. 3.

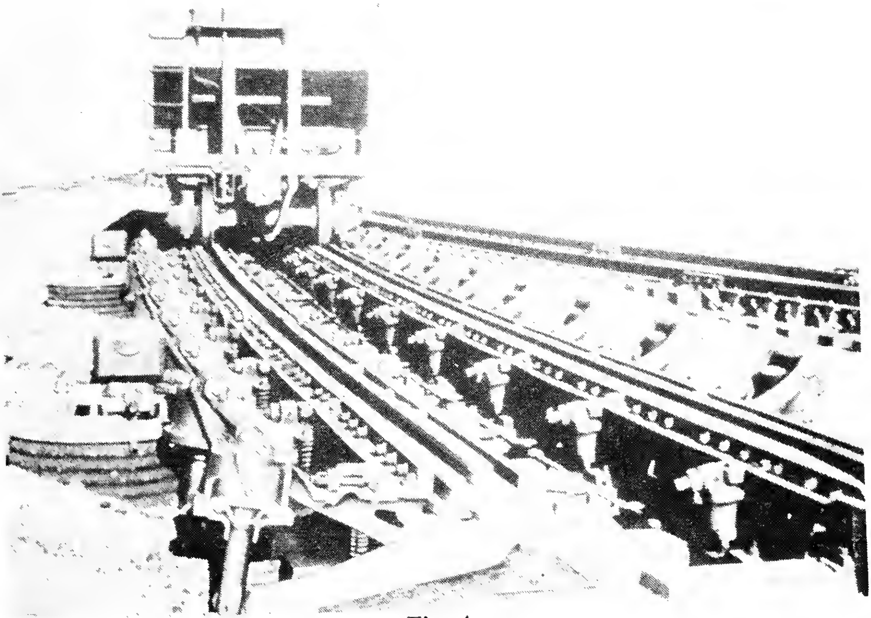


Fig. 4.

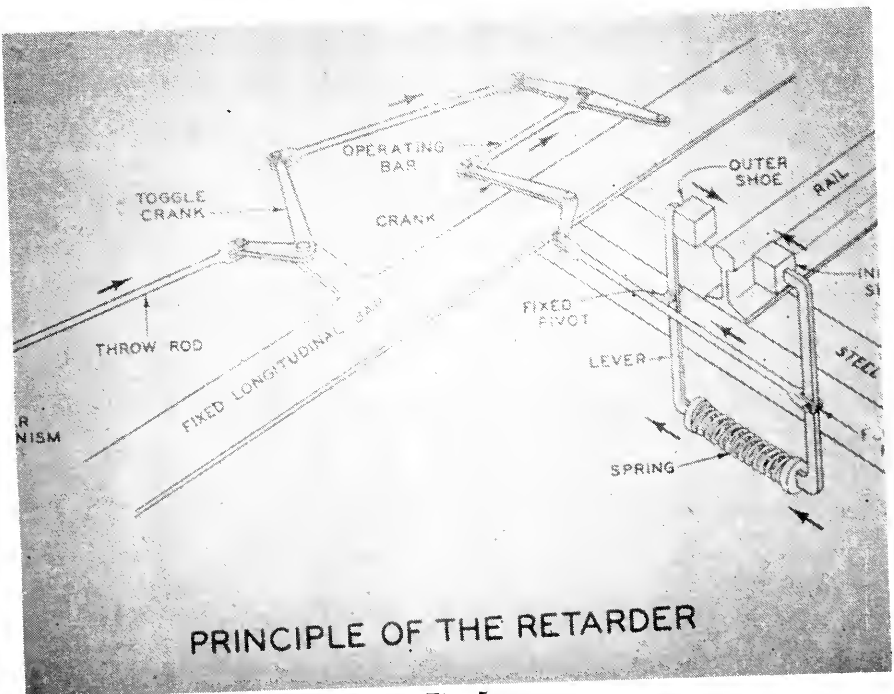

OPERATING
BAR
TOGGLE
CRANK
CRANK
OUTER
SHOE
RAIL
FIXED
PIVOT
THROW ROD
FIXED LONGITUDINAL
LEVER
SPRING
PRINCIPLE OF THE RETARDER

Fig. 5.

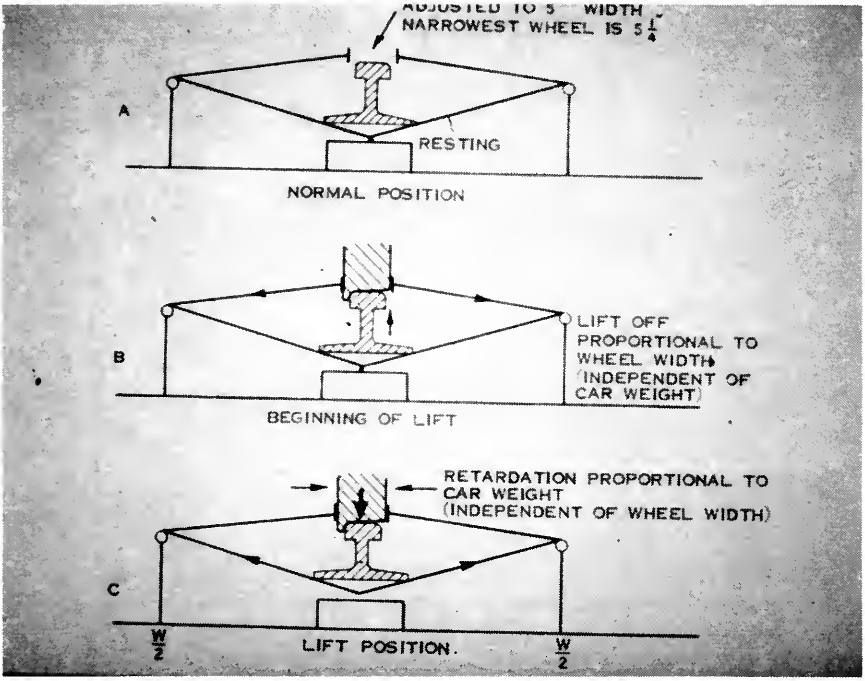

NARROWEST WHEEL IS $5\frac{1}{4}$
A
RESTING
NORMAL POSITION
B
LIFT OFF PROPORTIONAL TO WHEEL WIDTH (INDEPENDENT OF CAR WEIGHT)
BEGINNING OF LIFT
RETARDATION PROPORTIONAL TO CAR WEIGHT (INDEPENDENT OF WHEEL WIDTH)
C
$\frac{W}{2}$
LIFT POSITION.
$\frac{W}{2}$

Fig. 6.

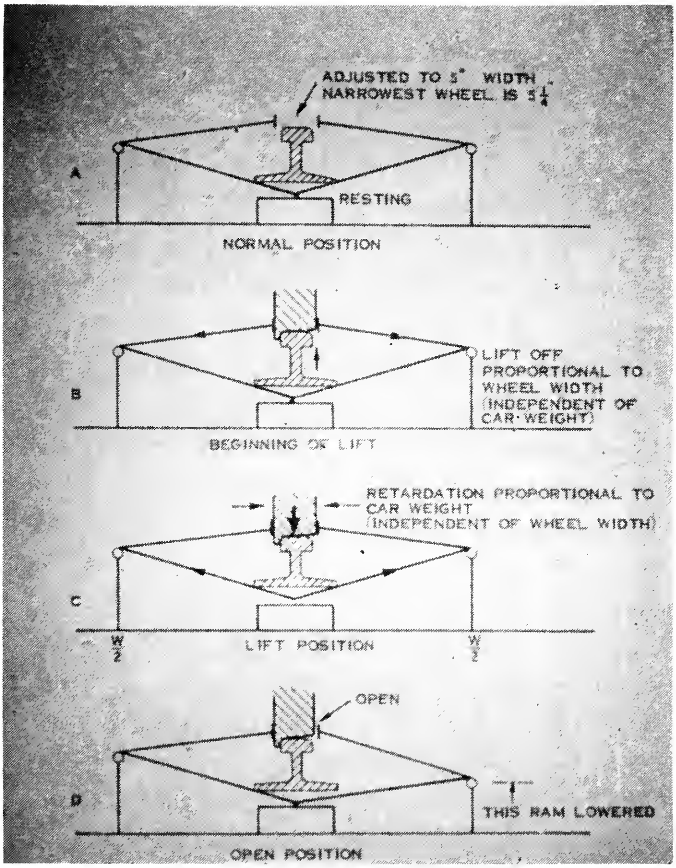

ADJUSTED TO 5" WIDTH
NARROWEST WHEEL IS 5¼
A
RESTING
NORMAL POSITION
LIFT OFF
PROPORTIONAL TO
WHEEL WIDTH
(INDEPENDENT OF
CAR WEIGHT)
B
BEGINNING OF LIFT
RETARDATION PROPORTIONAL TO
CAR WEIGHT
(INDEPENDENT OF WHEEL WIDTH)
C
W/2
LIFT POSITION
W/2
OPEN
D
THIS RAM LOWERED
OPEN POSITION

Fig. 7.

Fig. 8.

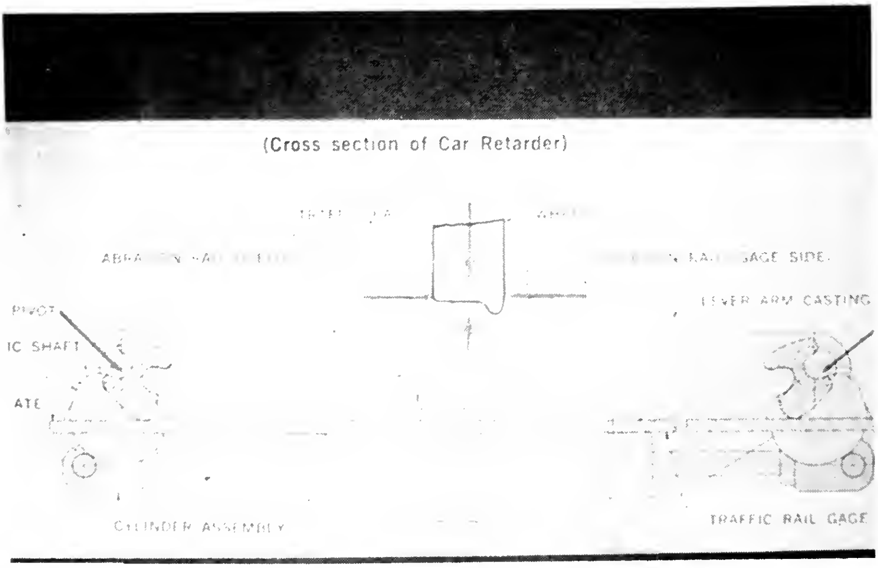

(Cross section of Car Retarder)
LEVER ARM CASTING
PIVOT
CYLINDER ASSEMBLY
TRAFFIC RAIL GAGE

Fig. 9.

Fig. 10.

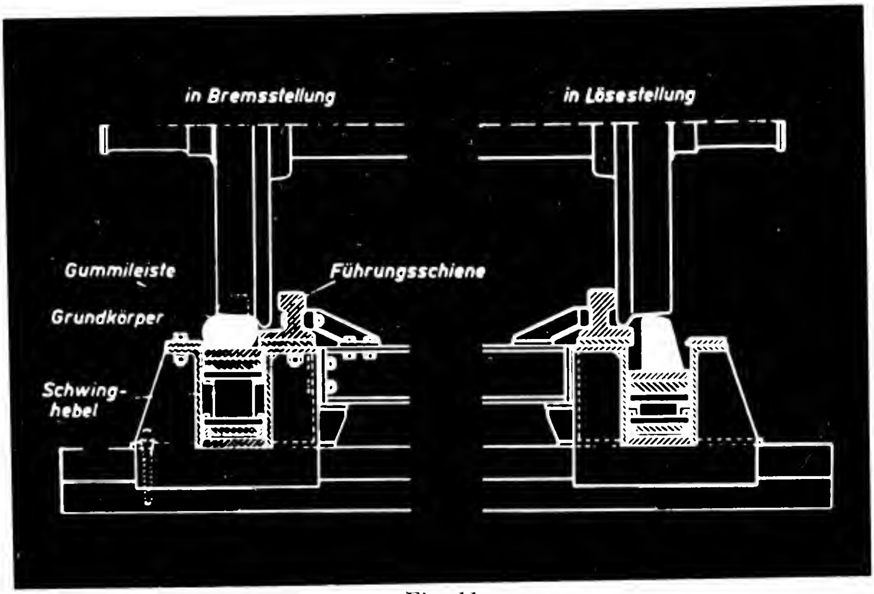

in Bremsstellung
in Lösestellung
Gummileiste
Führungsschiene
Grundkörper
Schwing-
hebel

Fig. 11.

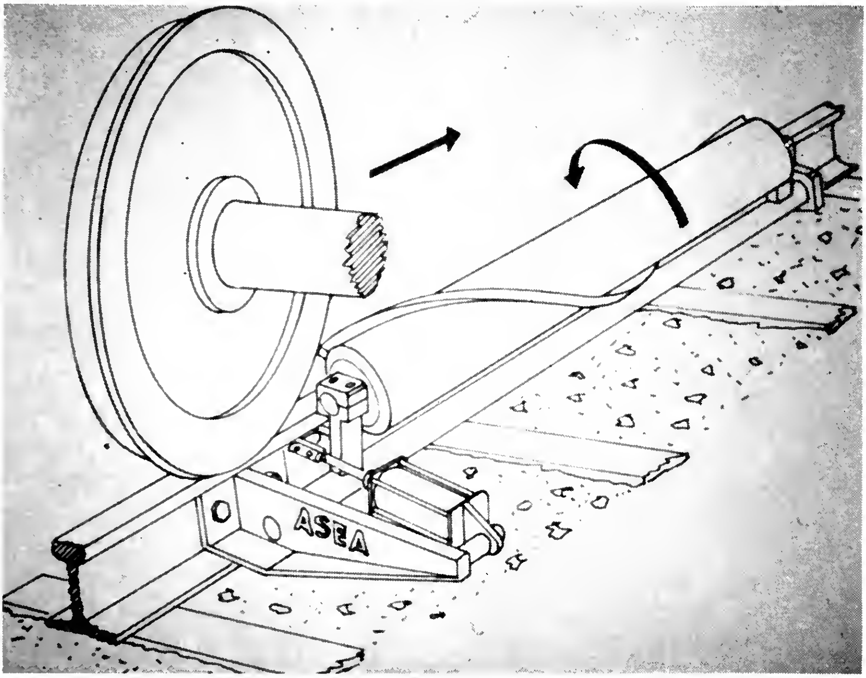

ASEA

Fig. 12.

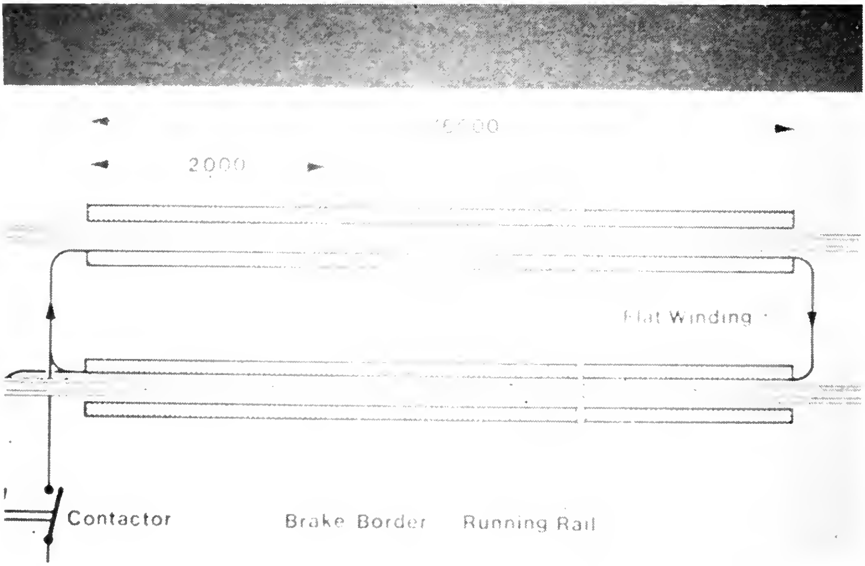

2000
Flat Winding
Contactor
Brake Border
Running Rail

Fig. 13.

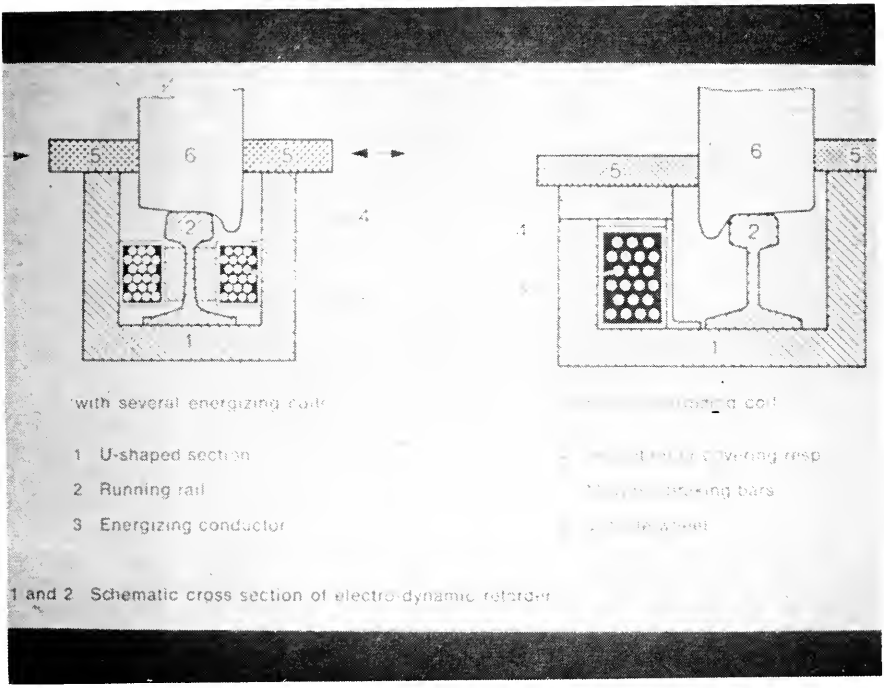

5
6
5
2
1
4
6
5
5
2
1
1 U-shaped section
2 Running rail
3 Energizing conductor
1 and 2 Schematic cross section of electro-dynamic

Fig. 14.

Recent Developments in Rail Joints and Adhesive Bonding Techniques

74–643–12

By W. SCOTT LOVELACE
Assistant Manager, Research & Tests
Southern Railway System

I. Introduction

This is a status report concerning the recent developments in rail joints and adhesive bonding techniques used in fabricating insulated joints, non-insulated joints, and certain track structures. I would like to take this opportunity to discuss with the engineering segment of the railroad industry, briefly, the highlights, the problems, and the benefits of adhesive bonding. Adhesive bonding techniques have been used most recently in (1) insulated joints, (2) non-insulated joints, (3) special high-strength joint bars for welded rail, and (4) frogs and crossings.

II. History and Outline of Adhesive Bonding Rail Structures in the United States

In the early part of 1969 the AAR Research Center in Chicago made preliminary tests on two basic types of epoxy-bonded insulated joints: (1) a German Federal Railway design, successfully used in Germany since 1959, and (2) a Netherlands Railway joint design in service on some European railroads. Both joints are similar in that they use full-contact bars with a bonded phenolic insulator. The German-designed joint proved superior to the Netherlands in the AAR laboratory tests, passing all structural tests and exhibiting a compression strength (or shear strength of the bonding) of over 800,000 lb. The joints tested were made for 132-lb rail sections. Fig. 1 shows a cross section of the German-designed joint illustrating the full-contact bars and phenolic insulation.

In early 1969, two railroads installed adhesive-bonded insulated joints in 132-lb rail, with hand-machined bars and hand-fitted insulation to evaluate their potential value as a substitute for the standard bolted insulated joint. In the fall of 1969, Southern Railway placed in service an experimental epoxy-bonded insulated joint in 132-lb welded rail where insulated joint life had averaged 3 to 4 months. This was in an area of high rail stresses and where bolt and joint bar failures had previously occurred. The epoxy-bonded insulated joint, installed in 1969, is in service today, after almost four years of continuous service, and over 100 million gross tons of traffic. The joint has not moved and the bonding is still intact, with only rail end batter to indicate a service period of four years. This particular joint was made with a phenolic insulation on each bar, a fiberglass matting between the bar and rail to evenly distribute the epoxy and phenolic thimbles for insulation around each bolt.

While adhesive bonding of joints in Europe in 1969 was an accepted practice, it had not yet been adapted for use on American Railroads. If a railroad wanted epoxy-bonded joints, it had to hand-bond custom-made bars, and fit insulation around each bar and bolt. Today, the adhesive-bonded insulated joints have devel-

Note: Discussion open until October 15, 1973.

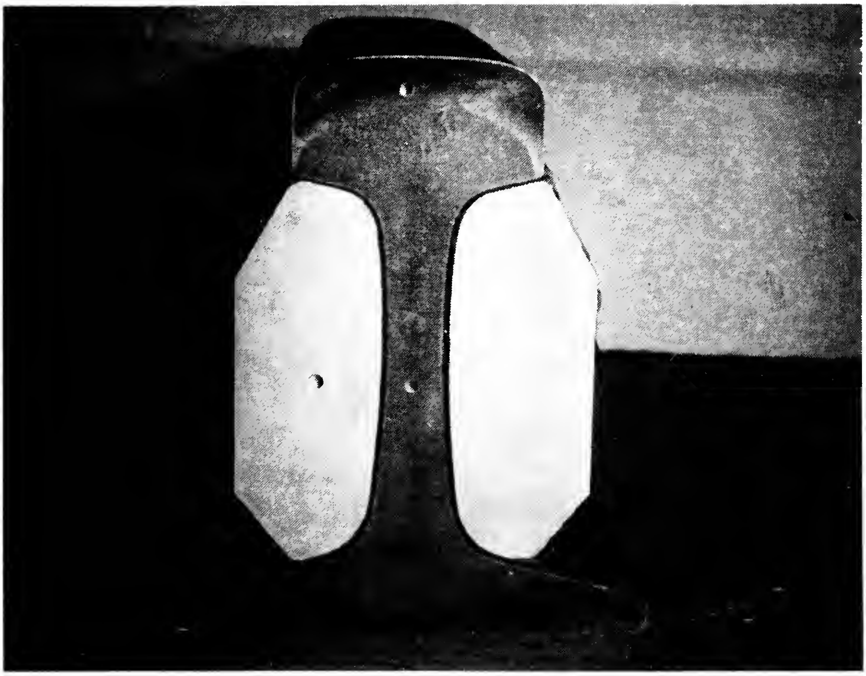


Fig. 1—Full-contact adhesive bonded bars applied to a 132-lb rail section. It can be seen that both bars contact the rail web from the head to the base fillets.

oped to a point where several manufacturers offer them in the form of kits or complete insulated joints, made into rail sections ready to be placed in track. Adhesive-bonded insulated joints are now made by at least four companies.

Construction of adhesive-bonded joints is based on one of two approaches: (1) the use of a fiberglass non-conductive material for the bar itself which is, in turn, epoxy-bonded to the rail, or (2) heat-treated, full-contact steel bars of approximately 100,000 psi tensile strength and meeting or exceeding the AREA specification for heat-treated joint bars. One company manufactures adhesive-bonded joints utilizing the fiberglass method; three others rely on steel bars. A typical insulated joint would consist of the steel or fiberglass bars, a one- or two-part adhesive to coat the contact area of the bars to the rail web, an insulator to cover the bars, and either high-strength bolts or Huck fasteners to secure the bars in place and provide sufficient clamping force for the joint assembly. The thickness of the adhesive bonding is critical and must be closely controlled, if maximum strength is to be obtained. A close-up of an insulated joint cross-section is shown in Fig. 2 where the phenolic insulation and two layers of adhesive bonding can be seen in the contact area between each bar and the rail web.

Since the initial installation of adhesive-bonded joints in 1969, the use of these joints has spread to numerous railroads with increasing variations in their application. For instance, Southern Railway has placed in service over 600 adhesive-bonded

Fig. 2—Close-up view of the full-contact steel bars and rail web. The adhesive bonding can be seen on each side of the phenolic insulation. The bonding gap in this joint is approximately 0.025 to 0.035 in.

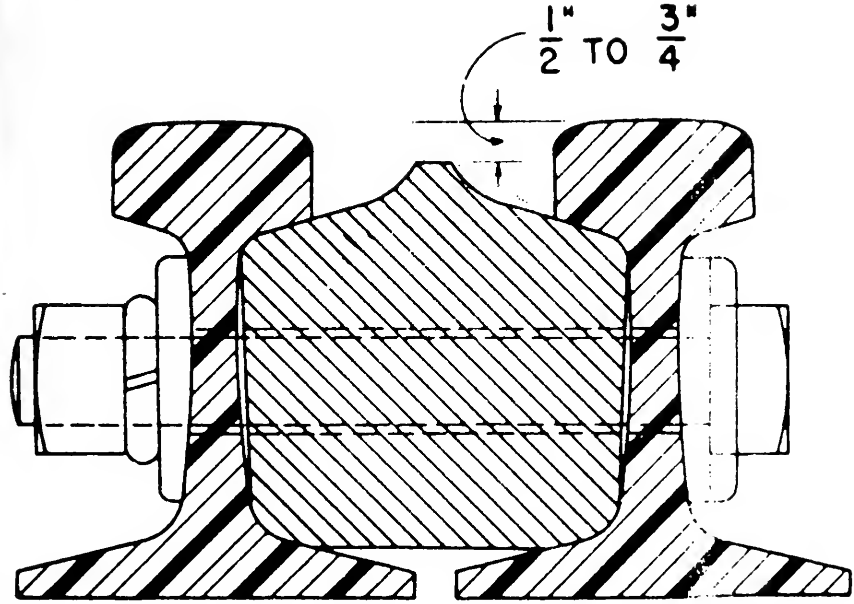
joints as part of its welded rail program and maintenance joint replacement. The use of these joints is steadily increasing throughout the railroad industry. The application of adhesive-bonded joints, whether they are insulated or non-insulated, is made in one of two methods: (1) pre-assembled by the railroad or manufacturer into completed joints in 10- to 39-ft rail lengths and then transported to track location and thermite-welded in place; or (2) by field installation where the joints bars, insulation, and adhesive are applied to the existing rail ends and a completed joint is made at the track location.

During the field installation there are several critical areas that must be closely controlled: (1) the grinding of the rail web to remove bolt hole burrs and raised rail identification markings, (2) sandblasting to remove oxides and mill scale, (3) alignment of the rail ends, (4) application of the adhesive to insure full coverage with no contamination, and finally (5) positioning of the bars in such a manner that electrical shorts are not created.

III. Recent Advancements in Providing Higher Strength Rail Joints and Track Structures

A. *Frogs*

Recent experimental bonding of No. 20 railbound manganese steel frogs has indicated it is practical to bond all, or a portion of, a frog before it is placed in



SECTION M-M

Fig. 3—Cross-section of a No. 20 railbound frog at the heel portion. The interface between the rails and heel block was fully bonded in this area.

track to eliminate movement between the parts. In one particular case, a No. 20 frog was disassembled, sandblasted, and epoxy-bonded at the manufacturer's facilities before it was shipped to the railroad for maintenance track work. To provide the necessary clamping force during curing of the adhesive, high-strength 1⅜-in.-diameter bolts, torqued to 1700 ft-lb, were used to secure the frog components. Most railbound manganese steel frogs are not completely suitable for adhesive bonding because of the large spaces between components; however, the heel portion of the frog fits together with small voids and can be easily bonded. As previously mentioned, significant strength is lost in the bonding when the adhesive thickness is increased over approximately 0.035 in. Fig. 3 shows a typical cross section near the heel portion of a frog and illustrates the interface that was adhesive-bonded. In some areas where the space was large between the rail and heel riser extension, a filler bar was placed in the opening to reduce the area of the void before applying epoxy.

While it is too soon to evaluate accurately the service performance of the adhesive-bonded frog, the first frog installed on the Southern Railway has had approximately 45 million gross tons of traffic and is remaining solid with no movement in the heel portion, and no tendency towards working under traffic.

Fig. 4—Two non-insulated 36 in. adhesive-bonded joints applied to 132-lb rail. This installation was made in track to existing rail ends and adjacent to a frog.

B. Adhesive-Bonded Non-Insulated Joints

To further reduce the maintenance at critical track locations, adhesive-bonded non-insulated joints are being used on an experimental basis to provide a stronger and more maintenance-free joint. Non-insulated adhesive-bonded joints, with full-contact bars similar to the insulated joints, but without the phenolic insulation, have been used to join rails together at frogs, crossings, and in welded strands. While these joints are experimental, and their use has been limited, they have been field applied to sandblasted rail in a similar manner as insulated joints. High-strength bolts are also used in these installations to provide the necessary clamping force while the adhesive is curing. Fig. 4 shows two non-insulated joints adjacent to a frog. These joints were applied to existing 132-lb rail having moderate end batter at a location in welded rail where joint maintenance was previously high. The service performance on these joints is limited but after six months service, under main-line conditions, they show no movement nor deterioration.

C. Special 8-Bolt Joint Bar Design

Experimental applications have been made on 8-hole full contact joint bars for use in continuous welded rail. Special 8-hole bars were fabricated by the Missouri Pacific Railroad for field testing in 136-lb rail, where rail forces had previously caused failures in standard 36-in. 6-hole joint bars. Calculations based on rail stresses indicated 6-hole joints were not sufficient to withstand the high pull-

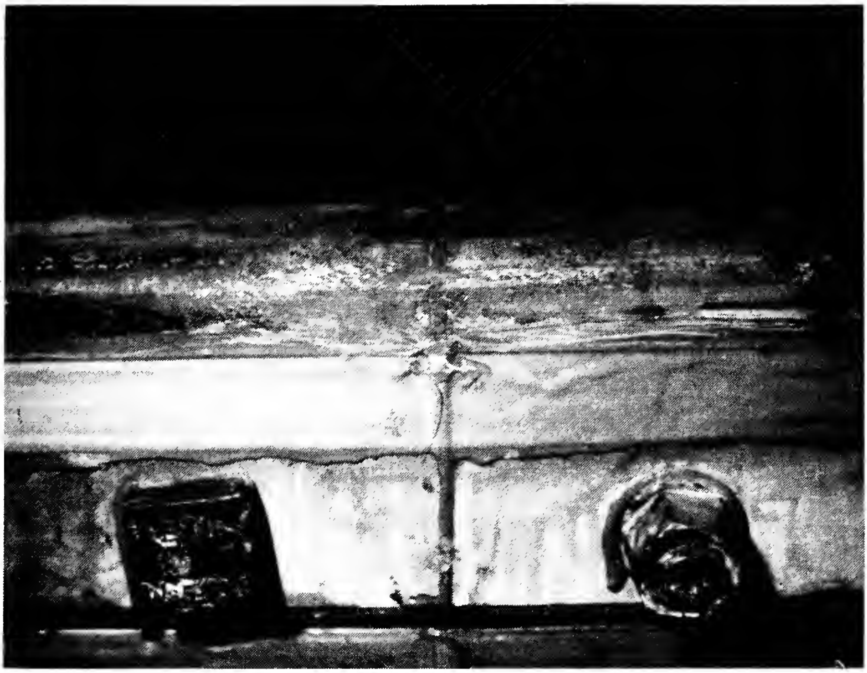


Fig. 5—An adhesive-bonded insulated joint with a narrow end post. Rail end batter on this joint was minimal after completion of a rolling-load test.

apart forces in their welded rail territory. In an effort to reduce joint problems, an 8-hole bar was designed and several were experimentally installed to evaluate their performance. The joint bars are 48 in. long and held in place with eight 1¼-in. high-strength bolts. No adhesive bonding was used in the assembly. After approximately four years of service the joints are reported to be performing satisfactorily with pull-aparts reduced significantly.

D. Narrow Rail Gaps in Adhesive-Bonded Insulated Joints

As a result of the inherent ability of adhesive-bonded joints to remain "frozen" and not move as rail forces change, the necessity for a large rail gap and corresponding end post is not as critical as it is in the standard insulated joint where movement occurs. Early in the development of adhesive-bonded joints, rail end batter was recognized as a limiting factor in service-life. By limiting or reducing rail end batter, the service performance of an insulated joint will most likely be extended, and it was with this thought in mind that narrower end posts were investigated.

A joint design incorporating a narrow rail gap has been used on the German Federal Railway for several years and was initially manufactured in Germany. This particular joint has a 5/32-in. rail gap as opposed to the standard ⅜-in. rail gap normally used in insulated joints.

Fig. 5 shows an adhesive-bonded joint with a 5/32-in. rail end gap and 36-in. bars for 132-lb rail after successfully completing a rolling-load test in the AAR laboratory. Light batter of the rail head can be seen at the rail gap but no significant metal flow has occurred. Several of these bonded insulated joints have been placed in welded 132-lb rail on the Southern Railway to evaluate the effectiveness of a narrow rail gap in reducing metal flow on the rail head. No rail end batter has developed in these joints; however, service at this time has been limited to approximately 50 million gross tons. It is expected that the narrow end post will reduce rail end batter and extend the effective life of the insulated joint.

IV. Limitations of Adhesive Bonding

There are several factors that represent limitations and must be considered when adhesive bonding is used in track work. The initial costs run higher than a standard insulated joint. However, the overall cost, considering service performance and maintenance cost, of the adhesive-bonded joint, should be significantly lower. Installation in the field is complicated by the need for preparing the rail ends for adhesive bonding. Contamination is a major factor and will affect the overall strength if precautions are not taken. Accessory equipment, such as sandblasting air compressors, torque wrenches and grinders, must be provided; in some cases hydraulic jacks to pull the rail ends together may be necessary. If prebonded joints are used, then the joints which are made out of track will require two thermite welds to place them in track.

At this point in the development and application of adhesive-bonded joints, a definite service-life expectation has not been fully established and may be affected to a large extent by the rail condition (head wear) at the joint. Adhesive-bonded joints in heavy-tonnage service for approximately four years have shown no deterioration in the bonding or insulation but have shown significant rail end batter in excess of 0.150 in. In some cases, the rail end batter will be a determining factor as to when the joint must be removed from service as it is not feasible to rebuild by welding rail end batter with the adhesive-bonded bars in place.

Failures of adhesive-bonded joints have been remarkably few and would, in itself, indicate the superiority of the adhesive bonding over conventional insulated joints. Of the adhesive-bonded joints installed on Southern Railway, only two have developed problems that necessitated their removal from track; one was a previous bolt hole crack in a rail where a field application was made and the other was an electrical short in the joint as a result of faulty assembly.

At this point in our testing, it would appear that the adhesive bonding in these joints will not be a limiting factor in the service life. But rather, based on results obtained to date, it would not be surprising to find the service performance limited by rail wear instead of the adhesive bonding or insulating materials used in these joints.

The Thermal Protection of Track Switches

74–643–13

By T. R. RINGER
National Research Council of Canada

The problem of track switches failing to operate satisfactorily in snow and ice conditions was brought to the attention of the National Research Council of Canada by the Canadian railways approximately 5 years ago. Our Associate Committee on Railway Problems assigned the task to the Subcommittee on Climatic Problems.

Following a preliminary and somewhat limited study of the problem a parallel three-phase attack was decided on. The first phase was to evaluate the performance of existing thermal methods of track switch protection by field and laboratory investigations. This necessitated setting up some standards for the evaluation program in the laboratory.

The standards for evaluation of track switch heaters arrived at were as follows:

1. Temperature 0°F
2. Snowfall rate 1 inch per hour
3. Wind velocity 20 mph

Each of the standards set has been exceeded in natural conditions, for example, snowfall rates of 3 inches per hour or greater have been recorded, temperatures may be well below 0°F, and the wind velocities may be above 20 mph; however, the simultaneous conditions chosen were considered to be sufficiently severe for the evaluation program.

The second phase was to investigate methods of protecting track switches in remote areas where only limited amounts of electrical power were available for the power supply to a thermal protection system. The third phase was a long-range program to consider alternate methods of alleviating or, preferably, eliminating the problem by non-thermal methods.

The facilities of the Low Temperature Laboratory include a large cold chamber approximately 50 ft long and a sizeable refrigeration plant. Temperatures lower than —65°F can be maintained while thermal loads of approximately 1,000,000 Btu per hour can be extracted. Wind velocities to 50 mph and snowfall rates up to 5 inches per hour can be simulated. The facility can exceed the requirements of the standards set in all respects.

Snow is produced in the chamber by a combination of three compressed air water atomizing nozzle arrays designed specifically for this purpose. One array is mounted overhead; this is the three bar assembly shown in Slide 1. Two spray nozzle arrays are mounted on the high-velocity wind generating fans. This arrangement allows snow production at low wind velocities, approximately 2 mph, or at velocities up to 50 mph. The snow produced is in the size range up to approximately 50 microns. Complete freeze-out is not obtained at 0°F prior to deposition on surfaces, thus this snow will build on vertical surfaces.

All three phases of this program have been or are currently being conducted; however, today it is the second phase that will be discussed.

The problem as posed by Canadian Pacific Rail was to provide adequate thermal protection for track switches in remote areas with an electrical demand not to exceed 100 watts. The evaluation work of phase 1 showed that a heater must

Note: Discussion open until October 15, 1973.

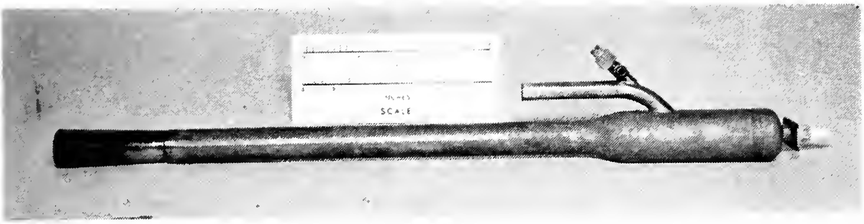
Slide 1.

have a thermal capacity of 250,000 Btu to protect a 22-ft switch under the standards adopted and that to be effective the heat must be directed to specific areas of the switch. The latter requirement necessitated a forced convection heat transfer mode. Additional requirements were dictated by operational necessities; for example, the ignition temperature of impregnated wooden ties, the soft ballast problem, lower ambient temperatures, etc.

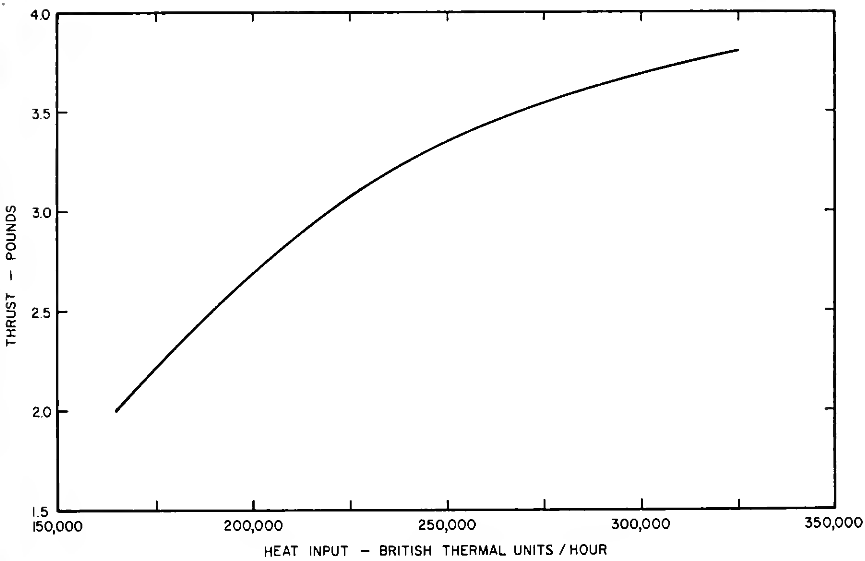
Various schemes were studied and ultimately a decision was made to investigate a switch heater based on the concept of employing a pulse jet air pump system. Pulse jets are best known from their application during World War II by the Germans in the form of their V-1 weapon, or the "buzz bomb" as it was more commonly known. The propulsion engine of the V-1 was a valved pulse jet of rather limited life. In the 'fifties further development was carried out on what are termed valveless pulse jets to obtain longer life. While life was extended, performance in terms of thrust was not improved and the pulse jet was virtually abandoned.

Both valved and valveless pulse jets have been developed as combustion heaters but with limited applications except for vehicle heating in Europe.

The valveless pulse jet has the inherent merit of producing heat and thrust with no moving parts and, if supplied with a gaseous fuel, requiring no other energy source for sustained operation once started. Although simple in concept the valve-



Slide 2.



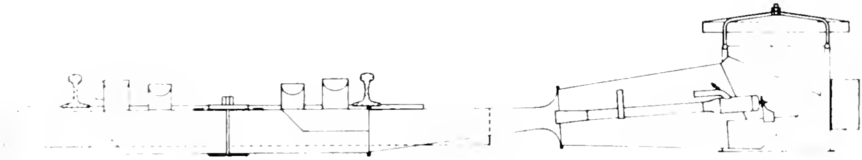
Slide 3.

less pulse jet mode of operation is sufficiently complex that analytical methods are limited in value for design and development.

Our early experimental work culminated in development of a pulse with a thrust output of the required value at the thermal capacity required. The Mark IV Model H pulse jet is shown in Slide 2. This is basically a combustion chamber with an air and fuel inlet and an exhaust outlet tube. The dimensions of the three main components dictate the pulsation frequency. This unit has a pulse frequency of approximately 125 Hz.

The thermal capacity and the thrust produced by this engine can be varied over reasonable limits as shown in Slide 3. Since the heat thrust curve is non-linear, exhaust gas temperatures rise with increasing fuel consumption. With a propane-fueled pulse jet the capacity can be varied by regulation of the fuel supply pressure. The nominal operating fuel pressure of the MK IV model is 5 psi to give a 250,000 Btu rating.

Having obtained a satisfactory heat and thrust source, work was then undertaken on a pulse-jet-powered air pump to give the total mass flow required at a



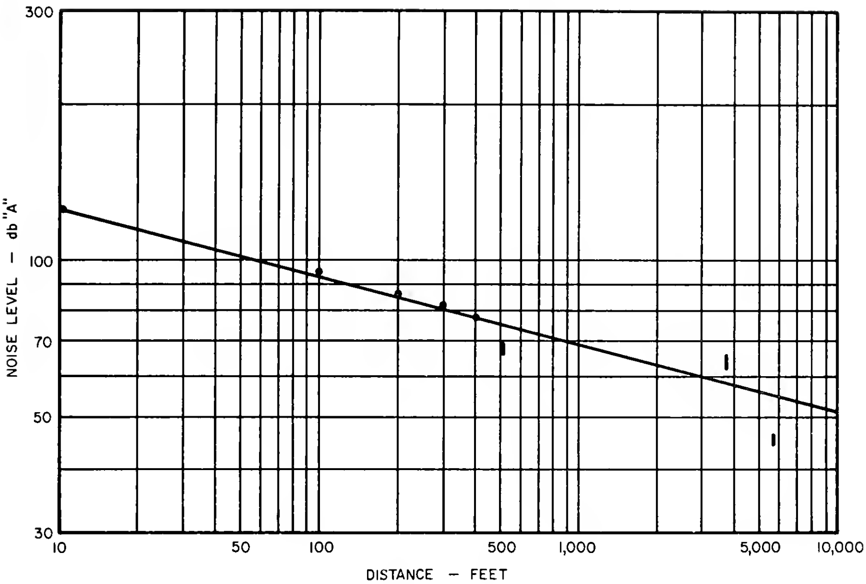
Slide 4.

safe exhaust temperature. An ejector pump was designed employing the pulse jet as the primary nozzle. The secondary nozzle is similar to a venturi since it has a convergent-divergent design. Slide 4 shows the overall design of the pulse jet heater as evolved for track switch protection. The sections include a protective cover to prevent direct ingress of snow, birds or other foreign objects; a reverse flow entry; a conical elbow secondary air flow duct; a convergent nozzle; and a divergent nozzle joining onto a between-tie cross duct supplying distribution nozzles.

This system moves approximately 1000 scfm of air with a temperature rise of approximately 200° F at the rated capacity of 250,000 Btu per hour. A static pressure exceeding 1 inch W.G. is attained at the outlet of the divergent nozzle.

Extensive laboratory tests were conducted on this heating method. Slide 5 shows the condition of a switch following a test under conditions somewhat more severe than the standards set for the phase 1 evaluation program.

Slide 5.



Slide 6.

Following proof of principle an extensive R & D program was undertaken before a prototype suitable for field use evolved. One of the more difficult problems encountered was that of providing a reliable automatic starting system for the pulse jet. Originally a compressed air starting method was developed to give the initial combustible mixture. While this was highly successful in the laboratory, the problems encountered at remote field installations eventually forced the development of a simpler, less expensive and more reliable method. Currently a small blower, approximately 1/20 hp, is used to supply the starting air.

Four prototype pulse jet combustion heaters have been installed on CPR track switches for the past two winters. The current prototypes incorporate the blower starting system. At the present time power requirements are approximately 150 watts during a one-minute starting cycle and approximately 25 watts during continuous use.

In the prototype construction these heaters produce noise at a sound pressure level of 120 dB at the source and therefore they are suitable only for remote locations. Slide 6 gives a survey of sound pressure measurements as a function of distance from the source. As you will note, a distance of 200 ft is required to obtain a noise level of 85 dB. Work is underway on a silencing program with a target of 85 dB immediately adjacent to the source.

One of the field installations near Perth, Ontario, is shown in slide No. 7. While the switch is clean, you will note that the snow level around the heater is close to the intake. The pulse jet has one major advantage over the usual forced convection switch heater. Snow-induced with the primary and secondary air is not a serious problem. Snow in the secondary flow is induced into the throat of the convergent–divergent nozzle and vaporized by the pulse jet exhaust. Normal con-

Slide 7.

centrations of snow in the primary air flow do not influence the pulse jet except by a minor reduction in temperature. An accumulation of snow if induced by the pulse jet will cause a flameout; however, an automatic relight feature in the control system assures continuing operation. A higher level air intake incorporated in an intake silencer has been developed and evaluated in the laboratory and is proposed for future field use.

To summarize, a combustion heater capable of protecting a track switch from snow and ice under relatively severe conditions has been developed. It provides forced convection heating without moving parts. Snow inlet induction is not a problem. The inherent reliability of the system is potentially higher than existing track switch heaters; however, it is a noise source and should not be considered for other than remote locations without silencing.

Impact of Track Safety Standards of the Federal Railroad Administration

74–643–14

By A. L. SAMS
Vice President and Chief Engineer
Illinois Central Gulf Railroad

One of the most discussed subjects these days in railway engineering and maintenance of way circles is the Track Safety Standards issued by the Federal Railroad Administration of the U. S. Department of Transportation. Starting in the middle or late 1950's and continuing through the present, expenditures on American railroads for track maintenance have been far from adequate to keep the track in good condition. Also during this period cars became heavier and trains longer, imposing greater demands on the track structure. The not unexpected result was a rapid increase in the number of derailments caused by track conditions. A few of these derailments involved shipments of chemicals which burned or exploded with spectacular effects.

In response to a growing concern by governmental agencies and others, the United States Congress enacted the "Federal Railroad Safety Act of 1970" on October 16, 1970. This Act provided, among other things, for the issuance by the Secretary of Transportation by October 17, 1971, of "initial railroad safety rules, regulations, orders, and standards," which were to be "based upon existing safety data and standards."

Among the body of existing safety data and standards were the AAR Engineering Division's "Recommended Minimum Track Inspection Standards," adopted on December 18, 1969, and "Recommended Standards for Track Maintenance," adopted on September 25, 1970. Both documents had been submitted to the Secretary of Transportation, the National Transportation Safety Board, and the Federal Railroad Administration in advance of the enactment of the Rail Safety Act.

The track inspection standards were developed by the Engineering Division's General Committee; the track maintenance standards by a committee composed of high-level, experienced track maintenance officers of AAR Member Roads.

During the months following the enactment of the Rail Safety Act, engineering representatives from railroads had frequent meetings with FRA representatives. The result of these discussions, and the discussions the FRA staff had with other interested parties and among themselves, was the publication in the *Federal Register* of June 23, 1971, of a set of proposed Track Safety Standards. Interested parties were invited to submit written data, views or comments. The proposed standards were far more strict than those submitted by the railroads. They were more than standards required for safety as the law provided. We filed our objections to the standards, including an estimate of the cost to comply. It was estimated that the one-time cost to bring existing tracks up to the proposed standards was $2.2 billion, or about $6,500 for each mile of track in the country, including side and yard tracks. The additional annual cost was estimated to be $140 million in excess of the current level of expenditures. The proposed standards were revised

Note: Discussion open until October 15, 1973.

and adopted in October 1971. After the initial standards were published in the *Federal Register* the railroad evaluation committee met again to re-estimate the effect on maintenance costs. The new estimates were a one-time cost of $1.63 billion to upgrade and additional annual cost of $116 million.

The standards adopted in 1971 provided for an effective date of October 16, 1972, except as to ties and track geometry for which the effective date is October 16, 1973. The initial standards were modified in January 1973 but the cost effect of those changes has not been evaluated for the entire American railroad system. Undoubtedly many railroads are making their own estimates. The critical question now is whether we must spend many millions of dollars to upgrade and maintain our tracks at a higher level to comply with standards. If so, where is the money coming from? If not, what alternate courses of action do we have?

The deteriorating physical condition of railroad fixed property is the direct result of excessive regulation of the industry. In the 20-year period from 1951 to 1971 average revenue per ton-mile increased less than 20% while the index of railroad wage rates and material prices increased more than 150%. Productivity gains made possible by industrialization, mechanization, mergers, innovations, and other cost-saving techniques have not been sufficient to offset the effect of inflation. Eventually it became necessary to defer much needed maintenance work. The situation worsens as requests for rate increases are denied while railroad operating costs continue to rise.

Unfortunately the 1970 Railway Safety Act did not make any provision for the railroads to finance the costs of complying with the safety standards. There appears to be no budget increases to upgrade the tracks, but we do have an alternative. For the purpose of the standards, tracks are divided into six classes as determined by speed. If a section of track does not comply with the standards established for it, the speed can be reduced to the classification in which it does comply. This is a time-honored system in the railroad industry for adjusting to a deteriorated track condition. The only difference now is that we have objective criteria to meet, which not all railroads have had in the past, and federal inspectors looking over our shoulders to make sure that we do impose speed restrictions where necessary.

If the standards were in all respects the minimum required for safety, then there would be little or no impact on railroad operations. The quality of railroad track is not determined by minimum safety consideration alone but is also affected by other factors, such as good riding conditions, requirements for service, prevention of damages to equipment and lading, and minimizing maintenance costs. Therefore, the track standards would impact track maintenance costs or speed only to the extent they go beyond safety requirements.

I should like to point out here some facts about the preparation of the standards. In the first place there is no clearly defined limit between a safe track condition and an unsafe one. No research has been conducted to establish the defects which cause derailments. No study has been made of derailments due to track conditions to determine precisely how they could have been averted. The assignment of cause of derailments is highly unscientific and subject to debate. The influence of factors other than track conditions is an important one which cannot be overlooked. Finally, the standards were written by persons experienced in track maintenance whose judgment may have been influenced more by their knowledge of good maintenance practices than by minimum safety requirements.

As a result it is likely that the standards are more restrictive in many respects than is necessary. An examination of some of the provisions will indicate this is a fact. One example can be found in the limitations on deviations from zero cross level on tangent track or from designated elevations on curves.

The usual practice in the industry is to incorporate up to 3 inches of unbalance in superelevating tracks on curves. This is done for reason of economy in reducing wear of the low rail from the passage of slow-speed trains. Experience has proved it to be entirely safe and the practice has been adopted in the Track Safety Standards. A negative deviation from the designated elevation on curves, that is, less superelevation than intended, does increase the amount of unbalance and does, therefore, cause a reduction in safety. On the other hand, however, a positive deviation can actually result in a safer operation.

Similarly, the permissible deviations from zero cross level on tangent track can be questioned. Unbalance on superelevation of a curve is comparable with an out-of-level condition on tangent track. It seems inconsistent to limit the deviation from cross level on tangent to ½ inch for Class 6 track when 3 inches unbalance on curves has been proved to be safe. At the other end of the scale slow trains can safely negotiate curves with 6 inches superelevation. Here again an inconsistency occurs in the standards in the limitation for Class 1 track of 3 inches deviation from cross level on tangent.

Provisions in the track standards which are too restrictive can also act to reduce safety. We are all faced with insufficient budgets for maintenance of tracks. The maintenance of way officer's principal function is to manage expenditures in the way which will produce the best results, including safety.

Funds spent for complying with unnecessarily restrictive standards will not be available for more essential purposes. Furthermore, existing practices which do promote safety may be changed to alleviate the adverse effect of a standard which is too difficult to meet. For example, the paragraph on defective rails specifies remedial action for small defects which have not reached hazardous size. In many cases inspection of rail in track by detector cars is being made at more frequent intervals than once annually as required by the FRA Inspection Standards. In order to reduce the cost of complying with the defective rail provision, a railroad may elect to lengthen the period of time between inspections.

These comments should not be interpreted as criticism of the drafters of the Track Safety Standards. The representatives of the railroad and FRA have made a sincere effort to write objective minimum safety standards. They have been handicapped by lack of information on the relationship between derailments and track conditions. The FRA recognizes the need for further research to overcome this deficiency. It has entered into a contract with Consad Research Corporation for the development of methodology or plan of approach for evaluating the economic impact of applying the safety standards. AREA Past President William J. Hedley is involved in this study. When this report is complete we should have a better understanding of the effect of the standards on railway operating and maintenance costs. Other research projects now under way should contribute more knowledge to the causes of derailments. Hopefully, this information will be used to make further revisions of the safety standards.

Except for these general comments it is difficult at this time to determine the impact of the standards. Ideally, there should be no adverse effect on costs. The tracks should be maintained in a better condition than the minimum required for safety. This may be true on some districts on some railroads but unfortunately is not representative of the entire system. Our principal efforts should be directed toward two objectives: (1) modification of the standards to eliminate any provisions not necessary for safety; and (2) to improve the condition of our tracks. I do think further changes in the standards should be made before October and from time to time thereafter.

Another factor to be considered is the interpretation of the standards. Some questionable areas have been cleared up by the January modifications but others still remain. Last year I requested estimates from our nine division engineers about the cost effect of the standards on each of their divisions. The response was quite varied from division to division, indicating some lack of understanding of the provisions in the standards and their effect on our track maintenance practices.

Still another factor to consider is the degree of enforcement of the standards by the FRA. Until these other questions have been cleared up we should reasonably expect some leniency in the enforcement. If, on the other hand, the FRA policy is to adopt a more rigid enforcement of the standards our costs can be greatly increased.

Finally, our experience in working with the standards has been too limited to make a good appraisal of their impact. We need more exposure to the standards and the FRA enforcement policy and inspection personnel before patterns will be established which can be used to determine their effect on our costs.

Applications of Mini-Computers on the Missouri Pacific

74–643–15

By H. L. CHAMBERLAIN
Engineer of Structures
Missouri Pacific Railroad

Introduction to Mini-Computers

Recent developments in computer technology have placed the availability of automated data processing within the reach of every firm and organization in the country. This has been accomplished through the use of mini-computers. Today the mini-computer has as much as or more power than its ancestors did back in the late '40's and early '50's and yet is only a fraction of their physical size.

Today there are more than 65 mini-computer manufacturers. This proliferation of the mini-computer has made it possible to have a chicken roasting in every pot being controlled by a mini-computer in every garage. Mini-computers can interface all the standard peripherals as their big brothers; i.e., card readers, line printers, plotters, disks, tapes, CRT's, etc. as well as some non-standard devices.

Applications of mini-computers are limited only by the imagination of the user. Two such applications for which the Missouri Pacific is using them is in the area of yard control and in-house time-sharing.

In-House Time Sharing

In constantly evaluating the services provided to the using departments, MOPAC found itself spending several thousands of dollars on time-sharing services

Note: Discussion open until October 15, 1973.

to outside vendors. With the use of a mini-computer as an in-house time-sharing system, savings in excess of $2500 per month can be effected. This system will serve the users who are presently using commercial time-sharing. They are:

The Economic Research Department
The Industrial Engineering Department
The Mechanical Engineering Department
The Civil/Design Engineering Department
The Traffic Department

Mini-computers can support higher level languages such as FORTRAN, BASIC, ALGOL, RPG, and COBOL. The system proposed for the in-house time-sharing will support interactive BASIC and batch FORTRAN. It will consist of 40K of memory (16 bit words), two disks of 4.8 mega-bytes each for user application storage, a magnetic tape device for exchanging data between the mini-computer and MOPAC's other in-house computer systems. Input to the system will be from existing teletypes (TTY's).

Yard and Terminal System

The other application where MOPAC is using mini's is for yard and terminal control which is a subsystem of MOPAC's Transportation Control System (TCS).

The mini-computer system will increase the efficiency of railroad operations at approximately 20 key yards and terminals. This Yard and Terminal System (YATS) will assist operations by: maintaining a computerized car inventory, supporting local management information requirements, generating car classification work orders, relieving the clerical data entry burden, and providing a real-time, on-line data base for local operations analysis.

The primary computer function will be the processing of this real-time, on-line system. The application requires interactive terminal support and a large volume of disk accesses.

YATS is designed to allow inclusion of the following computer peripheral equipment and associated controllers:

a) Card reader
b) Card punch
c) Line printer
d) Disk storage
e) CRT display(s)
f) RO teletypes
g) Data communications equipment

YATS is designed to handle a yard the size of MOPAC's Memphis yard (about 2,000 cars handled a day). The design will permit flexibility to handle an eventual growth to a yard inventory that handles 8,000 cars per day.

The design will permit capability to handle an eventual requirement of up to 12 CRT's and 10 TTY's. The system is capable of growth in bulk storage capabilities from 2 million to 12 million characters. The Core Storage size is 32K words. The entire application is being written in interactive BASIC.

Both the in-house time-sharing and the yards and terminal project will utilize a Digital Equipment Corporation (DEC) PDP-11/40 computer system.

The Distributed Computer System in Classification Yards

74–643–16

By JOHN J. DI PAOLA
Manager, Control Programming
General Railway Signal Company

There are two basic functions performed in a modern classification yard—process control and management information. Over the years an evolutionary process of sophistication has brought about the necessity of moving freight cars to their destination faster and more cheaply, safely and efficiently. The most efficient way to handle the two basic functions in the classyard is the Distributed Computer System (DCS).

An outstanding feature of DCS is its modularity. DCS modules are relatively simple components, each dedicated to a specific, clearly defined task, as shown in Fig. 1. The result is a new high in economy and reliability.

The system may be applied to new classification yards, especially built to take maximum advantage of the DCS concept. Such a yard would represent a truly dramatic advance in freight car classification. Also, DCS is very useful and applicable as a technique for updating existing yards and terminals. It provides a means for upgrading older facilities a function at a time, enabling the investment for the modernization program to be spread over a longer period. See Fig. 2.

Let us take, as our first example, an application of the DCS concept to a specific function—automatic routing or switching—as shown in Fig. 3. Such an application, not only economically competitive with relay switching systems, also offers today's technology and data base establishment with car following, inventory, and reporting functions on a per car basis from the established data base.

This application can precisely fit the needs of an older yard or a new one. It may (1) be commanded by the hump conductor through a conventional push-button input, or (2) be driven by a punched paper tape, or (3) receive its instructions from a switch list stored in a bulk storage device which is part of this module or part of another module.

The switching module offers the advantages of a computer-oriented system in that it implements individual car tracking as opposed to cut tracking, thus permitting catchup detection. Since it is a natural interface with at least teletype grade equipment, it may readily report its findings in sufficient detail so that immediate corrective action may be taken. And best of all, a record exists of performance in the form of a printout. The mini-computer in this subsystem makes possible easy communication with other computers in a larger interactive system.

The sensory equipment used for DCS automatic switching is the conventional tracking equipment—switch repeater contacts, zone presence detection in the switch zone (track circuit repeaters or loop circuit repeaters), and wheel detectors at the switch entrance point at the crest. Each switch is commanded through a 2-bit code.

In software support of automatic switching, it is important to note that the sophistications achieved in the monolithic digital computer applications (i.e., software switch protection, anticornering, fouling protection and catchup detection)

Note: Discussion open until October 15, 1973.

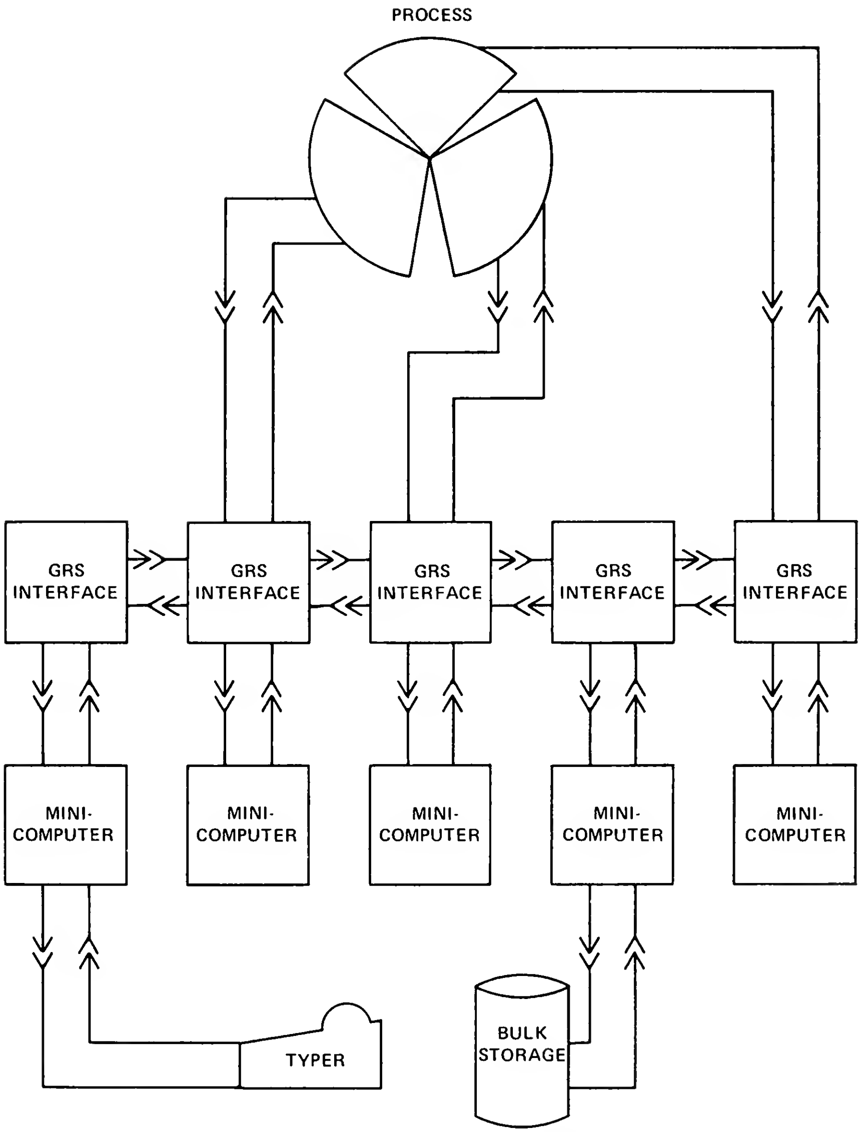


Fig. 1—DCS modules for a classification yard.

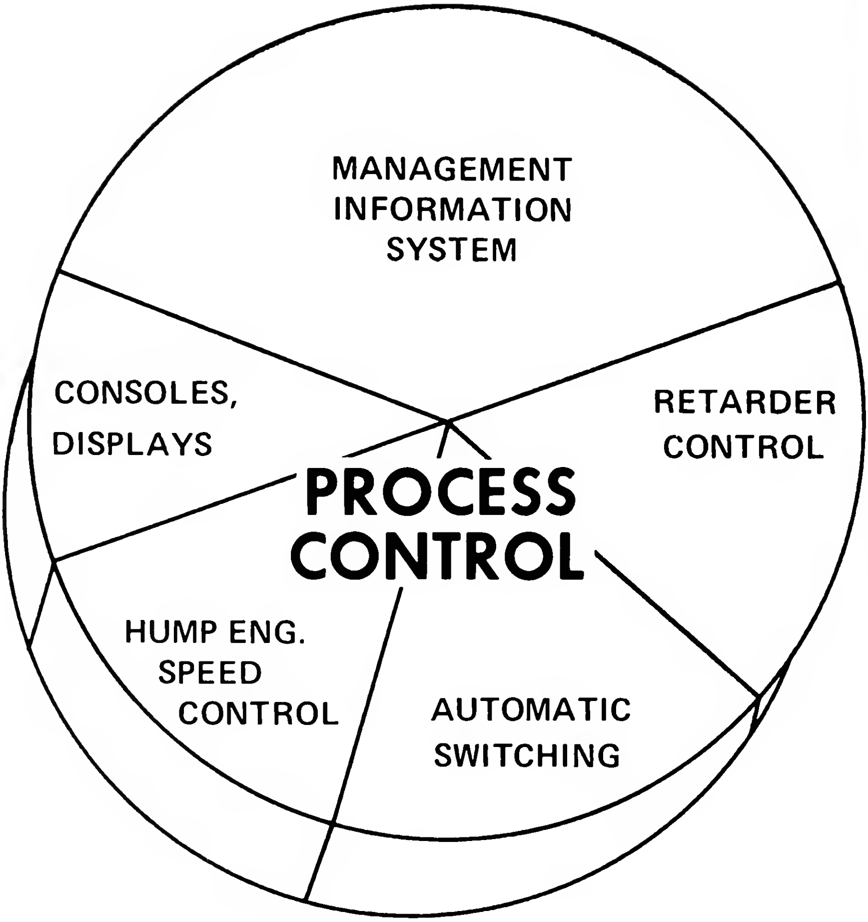


Fig. 2—DCS process control for class yard functions.

are enhanced and strengthened because of the modularity of the Distributed Computer System.

The modularity of the program is accomplished by the use of a tabular programming technique. Only the variables particular to a given classyard (the location of the lap switches, number of the tracks of the yard, etc.) are placed in the DCS system of table storage. As much as 75% of this software is common to all yards.

Also, because of its modularity, the automatic switching function is isolated so that it is walled off in the remainder of the process. Thus, during debugging or during a system expansion period, automatic switching continues to operate on a business-as-usual basis, protected from interference from the unbugged companion modules.

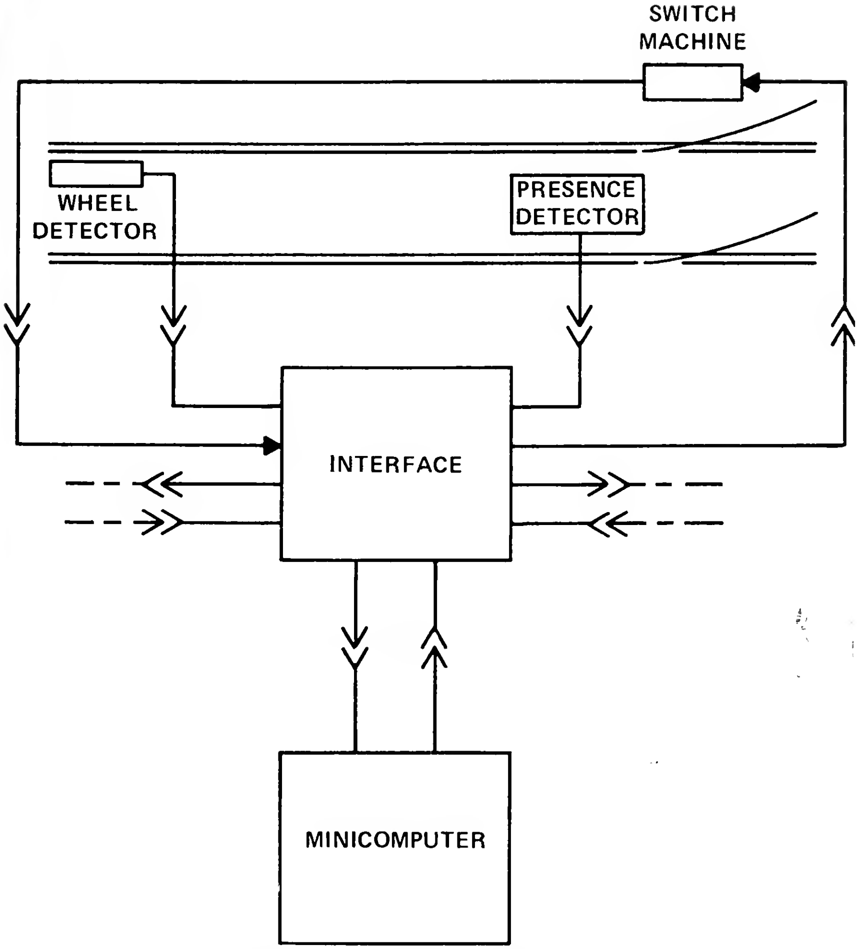


Fig. 3—The automatic routing function includes an interface from the mini-computer to track mounted equipment—wheel detector, presence detector, and switch machine.

Next, let us consider automatic retarder control with the DCS concept, as shown in Fig. 4. All of the retarders in the retarder control sections in the yard can be controlled with this module. The module may be applied as a stand-alone item in a small yard or in the updating of an existing yard. It can also provide primary automatic retarder control in a new, fully-automated yard as a module in the interactive control system.

The mini-computer calculates the required exit speed. The most modern method of retarder control is a direct digital control in which the speed control

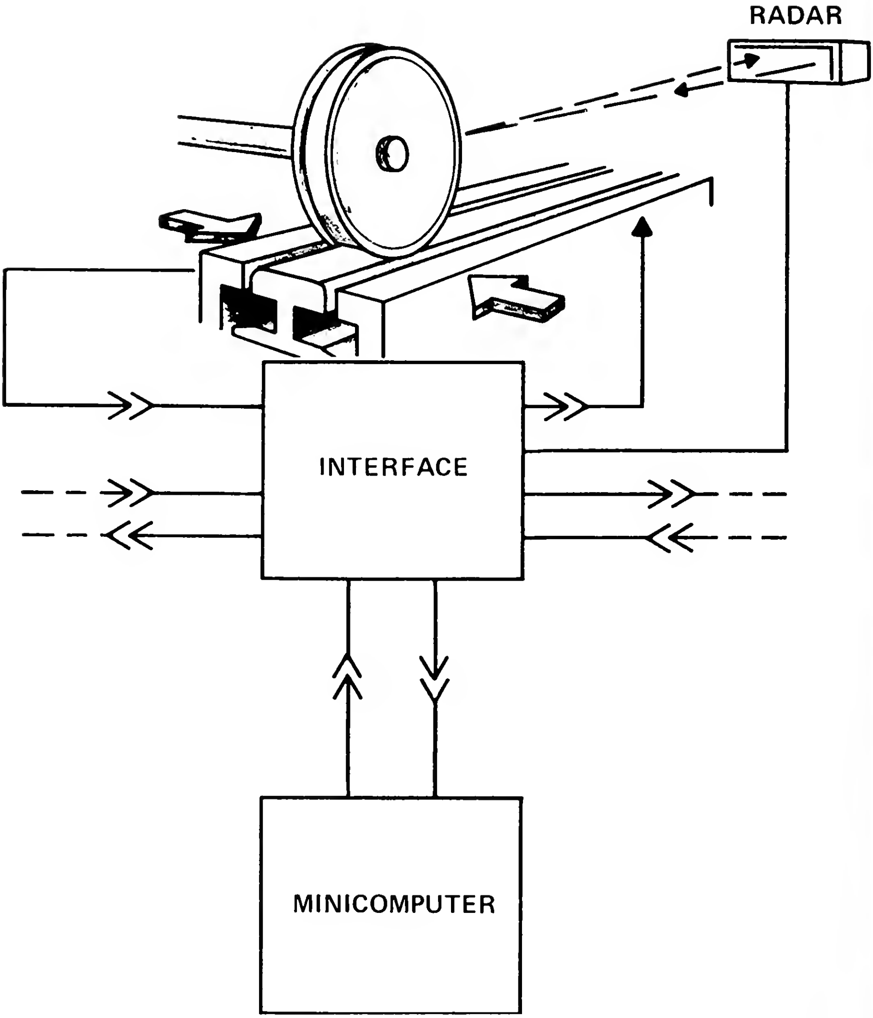


Fig. 4—The car retarder function includes inputs from the radar speed measuring unit and control of the car retarder operating mechanism.

loop is closed through the computer. The solid-state doppler radar is a digital device in a sense that it produces a pulse train at an audio frequency. With direct digital control, this pulse train, along with associated pulse event times, yields direct input to the computer. A frequency, or more properly period-to-velocity conversion, is made by the mini-computer program directly, with digital computer accuracy and consistency. Note that this entirely eliminates digital-to-analog converters.

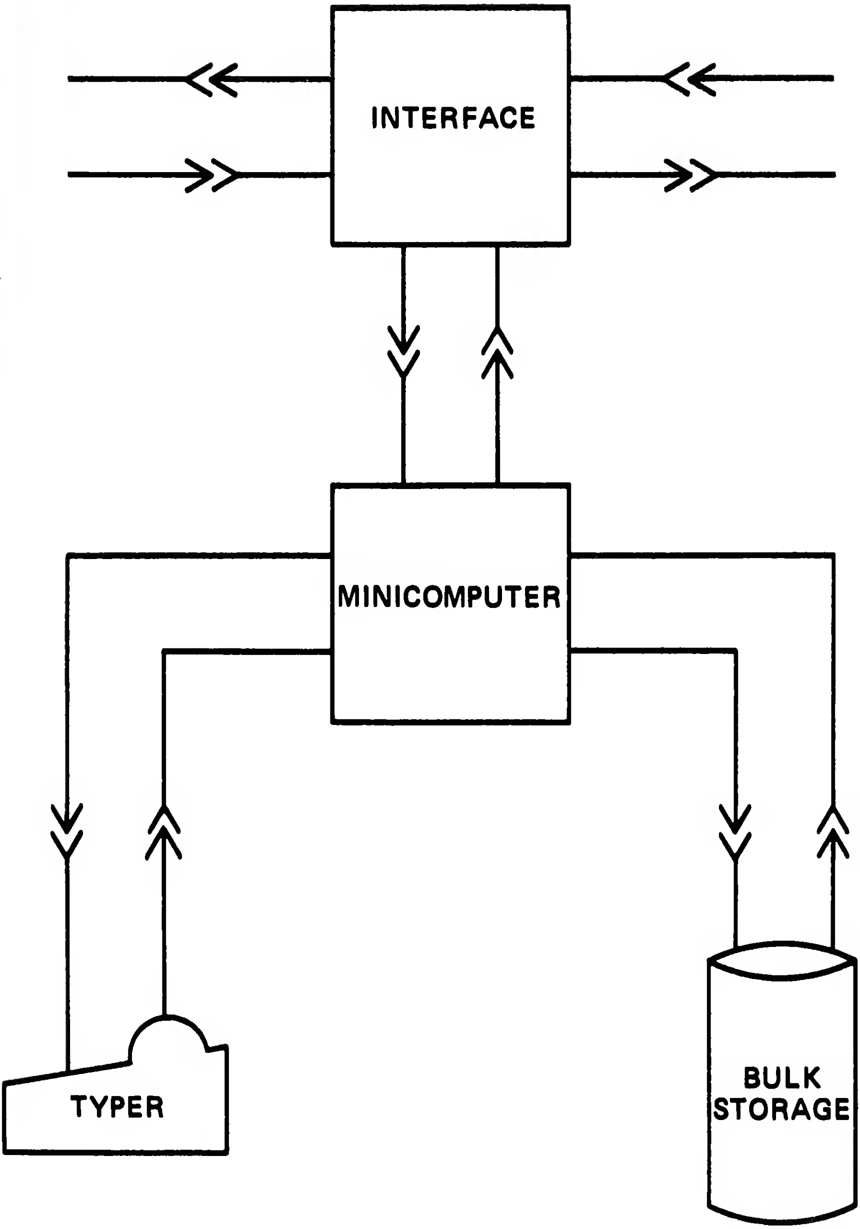


Fig. 5—Inventory and reporting subsystem.

Direct control of the retarders is also a natural digital function. The computer generates required position codes to operate each retarder, and these codes become direct output from the computer. Again, the control software for automatic retarder control is modular in nature and uses the most advanced techniques in classification yard control systems. As in the automatic switching module, the automatic retarder control software module is isolated from unwanted interaction by other modules.

Another module in the classification yard DCS system is the inventory in reporting subsystem, Fig. 5. This module does not communicate with the process to be controlled, but rather with the process controller modules. The business data processing and information retrieval programs, which run in this module, achieve the requirements of inventory reporting and supervision. Installation of this system does not compromise automatic switching or automatic retarder control.

There are other modules that may be added to a classification yard system such as automatic car identity, hump engine speed control, automatic fine tuning, technician and diagnostic modules, and a communication module, all of which may be isolated as independent functions to operate in the classyard system.

Sheffield Yard, presently being installed in Alabama, is the largest of any of the Distributed Computer Systems in service at the present time.

A Computer Oriented Rail Test System

74–643–17

By J. A. FRANKS and J. T. CLEMONS, JR.
Atchison, Topeka & Santa Fe Railway

Background of Rail-Flaw Detection

The failure of a rail due to an internal defect within the head of the rail, thereby causing a derailment and resulting in loss of human life, has been recorded in this country as early as 1911. Since that time, the prevention of service failures of rail in track has been one of the greatest problems of railroad maintenance. U.S. Patent Office history tells us that ways and means of detecting defects in railroad rail have been sought since 1877. A larger cross-section rail produced by the "control-cooled" process, along with several other improvements, have resulted in a more reliable rail than was being produced prior to 1936. Whatever the possibilities of eliminating failures by improvements in rail manufacture, it remains essential to concentrate on the problem of early detection of defects, and the present testing policy is aimed at this. Since the location of all defects within a rail is so important to avoid the possibility of future failures, it is necessary to develop effective methods of detection.

The initial detector cars were designed only to detect failures in the head of the rail. The technique was based on the magnetic field set up by the passage of the electric current through the head of the rail, and is known as the induction type of rail detection. A second type of magnetic detector car was developed which utilized an electromagnet to establish the magnetic field into the rail. Although

Note: Discussion open until October 15, 1973.

these methods were effective in locating the majority of defects, their usefulness and reliability in the joint-bar area remained in question.

The highest incidence of rail defects or failures occurs in the bolt-hole area. It is fundamentally a fatigue failure and its occurrence is influenced by such factors as speed, axle load and traffic density; but more particularly by angle bar fit and tightness and the degree of support given by the track structure. It represents a growing problem in that at a critical length the fatigue crack changes into a brittle fracture propagating through the entire rail section and, with increasing speed and axle loadings, there is evidence that the critical crack length at which transformation to brittle fracture occurs has decreased. This demands increased sensitivity from detection methods, increasing frequency of inspection and immediate rail removal when a defect of this type is found.

After many technical problems relating to the ability to couple ultrasonic testing to adverse track conditions had been solved, a new dimension was added to joint-area testing. The Audigage provided a concise but expensive means of testing these areas. Although the number of joint-area defects found increased tremendously, one could hardly expect it to be economically feasible to test the large amount of track with the periodical frequency required.

State-of-Art Testing

Ultrasonics provided the railroad industry with a very fast and capable method of testing the entire section of rail. With the test system producing such tremendous amounts of information about the rail, the automated test problem became one of communication between the test equipment and the detector car operator. In order to convey this vast amount of information to the operator in a form he can readily utilize, several display systems have been developed.

Types of Rail Display

The most common display has been the paper-tape and event-recording pen type, which is simple to operate and maintain, relatively inexpensive, and extremely reliable. This type of display can be improved by increasing the speed with such techniques as power switching transistors and faster pen action. However, even with these improvements, the resolution is inadequate for reliable operation in the joint-bar area except at very slow test speeds. Another system has been developed that provides a method of direct display which enables the operator to view the longitudinal cross section of the rail by means of dual cathode ray storage tubes operating in a B-scan mode, similar to airborne radar displays. The disadvantages of any type of direct and real-time display of the joint-bar area are apparent with some thought to the test problem.

Standard test speed for magnetic test cars is approximately 10 ft per second, or almost 7 mph. In order to provide the operator with enough time to evaluate all information provided by the test system as well as a visual check of the rail, at least 6 seconds are required. This time represents about two standard rail lengths on each side of the car. Any display used must be capable of retaining the rail information at least this long in order for the operator to evaluate the output of the test equipment, and visually verify this information before the decision is made concerning the possible hand-test or closer inspection. On a paper-tape display this retention is no problem, since in normal operation the paper tape displays at least five rail lengths continuously. With any direct display system, the problem has been to provide the operator with enough visual resolution to detect less than an inch-long defect within the joint-bar area while maintaining at least two rail lengths, approximately 60 ft, available for analysis for at least 6 seconds. This remains a problem due to the fact that only about 8 percent of the rail lies within the joint-bar area.

Method of Automated Rail Testing

In order to circumvent this display restriction, means were sought to produce a logic system capable of displaying joint-area defects to the operator only when all logical decisions possible had been made by the equipment. This idea was approached by two different methods. The first method consisted of a monostable timing circuit used to produce a pen indication only if the length of the base echo loss exceeded the length set into the equipment by the operator, and if there was a definite echo returning from the web-area of the rail. The web-area echo logic was used in order to exclude adverse track conditions, e.g., rough joints causing loss of acoustical coupling to the rail, separation of weld metal from the ends of battered joints, vertical split heads, and other defects causing loss of a base echo. Because of the lack of precision encountered with this method, another approach was tried. The second method utilized decade counting circuits to count the transmitter pulses which failed to produce a base echo. An indication was provided to the operator only if a preset number of pulses failed to return from the base of the rail, and a web-area echo was present within a specified time. An attempt to "gate out" the top of the bolt hole and accept any other web-area echo proved fruitless because of the large number of randomly placed bond wire holes as well as considerably worn conditions of the various size rails.

Although both of these methods work quite well, they had two serious drawbacks. Both methods utilized the basic principle of comparing the length of the bolt hole with a set standard length, determined largely by the speed of the test vehicle. With considerable effort, the speed of the test vehicle can be controlled with enough accuracy. However, to assign a set standard allowable length to a bolt hole is impractical due to several factors, of which elongated bolt holes as well as the different basic sizes of rails and their corresponding bolt hole lengths comprise only two. The main consideration in not adopting either method is founded on the sheer practicality of either being useful to the point of being able to offset their inefficiency in terms of cost involved in having to hand-test every defect indication received by the operator. If only one false indication per mile, or 600 joints, is received, the time involved in hand-testing would account for the rail test car being slowed by a factor of nearly two.

The necessity of hand testing every indication is a result of the paper tape display being capable of providing the operator with only the general information about the joint. The length and nature of the possible defect cannot be related to the operator.

Computer Rail Testing

In the Computer Oriented Rail Test System, the bolt holes are not compared against a set standard, but against each other. In other words, if all bolt holes in a rail are the same size, and the correct distance apart, they are not defective. The computer system consists of a general purpose 4096-word 16-bit digital computer. This computer is capable of performing over one million decisions per second. With the ultrasonic receivers on the two vertical channels alone producing over 2000 words of information about the rail per second, it is only logical that as much of this information as possible be used to provide the operator with the necessary information to make a decision.

Computers of this type are ideally suited for this type of real-time data acquisition and reduction. Not only can the computer check the distance between bolt holes and the length of each bolt hole, it can actually check the contour of the bolt hole and defect, discarding bond wire holes and other normal conditions. The information about the defect can be displayed by the computer in a variety of ways. However, since the primary function of the computer is to locate bolt hole breaks and convey to the operator as much information as possible about these defects without distracting or confusing him with unnecessary information, a simple numerical readout is used. On each side of the paper chart table are placed two rows of six numerical readout tubes. The inside row contains the relative length of each of the bolt holes last tested. Although between 10 and 30 words of information are made available to the computer by the vertical ultrasonic receivers for each bolt hole, the computer assigns a number between zero and nine to each bolt hole. The outside row is simply a storage of the information on the previously tested joint, thereby retaining information at least six seconds or two rail lengths.

As each new joint is tested, the information is displayed on the inside row of readout tubes, then shifted to the outside row after the next joint is tested. If the joint meets the requirements programmed into the computer, the numerical readout digits for the joint will not agree, i.e., 5–6–5–5–5–5 (signifying a probable bolt hole break in the second bolt hole tested). A small audio alert will sound, and a light above the row of numeric indicators will begin flashing, indicating in which joint the probable defect was detected. As the joint following the defective joint is tested, the information concerning the defective joint is transferred to the outside row with the row indication light also shifting. With this type of display, the operator is free to evaluate the information of the entire rail on the conventional paper tape, and by only glancing at the row of numeric indicators specified by the row indication light upon detection of defect, can make a quick and simple decision based on his visual evaluation of the rail as well as general rail conditions.

Although a series of latches and decimal comparators could measure the bolt holes by the base-loss and web-area return echos, some system would be required to distinguish the difference between bond wire holes, odd numbers of bolt holes as in step joints, distance between holes, and other normal rail conditions. Since a general purpose digital computer with a memory has the ability to store the vital information about the entire joint before display, compared to the ability of a specialized test system to display only the real-time information, many steps of checking can be performed upon the joint in its entirety before display is effected.

The capability enables the computer to extract vital information about the bolt holes as well as their spacing and number before providing the operator with the information he needs to make a decision concerning the defect. The numbers displayed on the numeric indicators are assigned *by the computer* and are only relative to each other and in no way represent the actual length of the bolt holes. Although a bolt hole break 1 inch long might be displayed as a 4–4–4–4–6–4, a 2-inch bolt hole break might be displayed as a 3--3–3–3–7–3, enabling the operator to grasp the relative size of the defect regardless of the rail size or bolt hole size. Because of the computer's ability to store and display the information about the entire joint, after it has been tested and evaluated, this relative sizing can be accomplished quite easily.

At the same time this information is displayed on the numeric indicators, a standard television set, operating directly from the output of the computer, diagrams a direct view of the joint and defects and retains that picture until the next defect is detected. A manual over-ride switch can enable the operator to hold a specific defect on the screen indefinitely if he so desires.

Summary

When the cost of independent circuit components required of a specialized test system as well as the labor and development manpower is evaluated, it can be seen that a computer system that can be updated simply by changing a program step on the switch register or teletype in a matter of minutes is a much better investment. We feel that the ability of the entire test program to be rapidly updated enables the operator to continue improving the test program until the full capabilities of the computer are realized.

The results of the Computer Oriented Rail Test System have been quite rewarding. Prior to CORTS, only about 10 percent of the total defects by the standard AAR type magnetic detector car equipped with paper tape and vertical ultrasonics were joint-bar area defects. Within the first 10 months of operation, the ratio has jumped to over 55 percent. With continued up-dating of the computer program, that percentage is expected to rise even further.

It should be realized that a considerable difference exists between the ability of a rail test device to test ideal track conditions and those actually encountered. The human element of rail testing can never be replaced, and computer-aided display systems are far from an ideal test system; however, we feel that the computerized test system represents a very flexible, reliable and low-cost improvement.

REMARKS BY CHAIRMEN OF TECHNICAL COMMITTEES

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Committee 1—Roadway and Ballast

Remarks by Chairman M. B. HANSEN*
Assistant Engineer Location and Construction
Canadian National Railways

The Manual recommendations of Committee 1 are published in the November–December 1972 Bulletin, No. 640, pages 55 to 105, incl. The committee's annual report is published in the January–February 1973 Bulletin, No. 641, pages 307 to 309, incl.

During the past year your committee held three meetings—two one-day meetings in Chicago and one two-day meeting in Cincinnati, Ohio. At the latter meeting we toured the Armco steel plant at Middletown, Ohio. The fabrication of culvert pipe and structural steel plate for culverts was especially interesting to the members.

Three sections of Part 1, Chapter 1, of the Manual, namely, Exploration and Testing, Design, and Construction of the Roadbed, have now been completed and have been submitted for adoption in the Manual. Work has commenced on the last section, entitled Maintenance of Roadbed.

Work is progressing on all other assignments in updating and revising the existing Manual data.

There have been a number of changes in the chairmen of subcommittees since the last report; these are as follows:

J. L. Vickers, division engineer, Burlington Northern, Inc., is chairman of Subcommittee 3—Natural Waterways.

R. L. Williams, special engineer, Illinois Central Gulf Railroad, is chairman of Subcommittee 5—Pipelines.

J. B. Farris, assistant engineer, Southern Railway System, is chairman of Subcommittee 6—Fences.

W. J. Sponseller, engineer of construction, Penn Central Transportation Company, is the new secretary.

This ends my term of office as chairman of Committee 1, and I extend my thanks to the hard-working chairmen of the subcommittees and their members for easing my task as chairman.

The new executives of Committee 1 will be:

E. L. Robinson, general manager, Haystack Mountain Development Company, Atchison, Topeka and Santa Fe Railway, as chairman.

N. E. Whitney, assistant bridge engineer, Illinois Central Gulf Railroad, as vice chairman.

* Presented by Vice Chairman E. L. Robinson in Mr. Hansen's absence.

Committee 3—Ties and Wood Preservation
Special Committee on Concrete Ties

Remarks by Chairman G. H. WAY*
Assistant to Vice President, Research and Test Department
Association of American Railroads

My report today covers the activities of the past year and the plans for the coming year of two committees. The first of these committees is Committee 3—Ties and Wood Preservation, and the second is the Special Committee on Concrete Ties. While the names of these committees might lead one to believe that their activities are similar, if not overlapping, I assure you that they are not.

Committee 3 is a standing committee dealing in an area where technological developments have not been rapid but where the problems of economics, supply, processing and handling have been, and by all indications, will continue to be, paramount. The committee has historically been manned by two groups; those whose daily activities involve the inspection, selection and purchase of timber and those who use what the first group provides.

During the past year, Committee 3 has been undergoing considerable reorganization. In addition to a new chairman and vice chairman we have three new subcommittee chairmen. The major activity for the past year has involved complete revision of the Manual, which has been progressing under the capable direction of Jack Fudge. I promise Jack that during the coming year we will endeavor to give him the necessary help to complete this urgent and important task.

Unfortunately, last year, due to travel restrictions on many members, it was necessary to cancel our planned inspection of service tests of ties of several species on the Union Pacific. We hope that this trip can be rescheduled in the near future. The inspection trip this year will include the joint FRA/Santa Fe test track near Aikman, Kan., and will also revive our past practice of visiting tie treatment plants to observe their degree of adherence to AREA specifications.

A third area of activity to which we are giving increasing concern is that of tie disposal. In this connection, we have established contact with personnel of the Forest Products Laboratory at Madison, Wis., and are providing them information for use in their studies of methods to recycle used tie material.

The Special Committee on Concrete Ties is a "horse of an entirely different color." As you are aware it is made up of active members from the Committees on Track, Ties, Concrete Structures and, most recently, Roadway and Ballast. The technological developments with which this committee is concerned are rapid. So rapid in fact, that from one meeting to the next we sometimes must relearn the entire text book, only the text book hasn't been written as yet. At this time last year there was carefully guarded confidence that the revised specifications for concrete ties could be released by late 1972. Then in September, as those of you who attended the Roadmasters' and B&B meetings and saw and heard John Weber's presentation will remember, the balloon was burst by the discovery of positive bending cracks in a series of concrete ties recently installed in Santa Fe track. Your committee withheld release of its revised specifications pending further investigation of the exact nature, cause and seriousness of those cracks.

* Presented by C. P. Bird, vice chairman of Committee 3, in Mr. Way's absence.

Several ties containing cracks were sent by Santa Fe to the Portland Cement Association Laboratories at Skokie, Ill. In December we met at Skokie in company with Committee 545 of the American Concrete Institute to examine cracked ties and to witness laboratory testing. One of the tests, which was proceeding at the time of our visit, was a repeated-load test of a tie which had cracked in service. Its purpose was to determine the effect of existing cracks on load carrying ability and life expectancy. The test has just been concluded after over 5 million cycles of especially severe magnitude and has contributed a great deal towards Bill Autrey's [chief engineer of the Santa Fe] and our composure and peace of mind. Cracks of the type investigated constitute neither an immediate hazard nor a severe limitation on life expectancy.

None the less, crack-free concrete ties are a worthwhile if not an absolutely essential goal of this committee.

We suspect, and our investigation to date supports the position, that there is considerable interaction between concrete ties and the nature, composition and compaction of ballast. While such interaction was no surprise, the degree of influence has been.

Again we express guarded optimism that this September–October AREA Bulletin will contain the revised specification. It will call for increased bending strengths for ties, and will include specific recommendations for ballast usage as well as several revised acceptance test procedures.

Committee 4—Rail

Remarks by Chairman V. E. HALL
Office Engineer
Atchison, Topeka & Santa Fe Railway

The report of Committee 4—Rail, appears on pages 317 to 355 of the January–February 1973 Bulletin, No. 641, and includes a progress report on Assignment B—Revision of Manual. In this connection a letter ballot was recently sent out proposing revisions to Section 12—Workmanship, of the Rail Specifications. This assignment will be continued this year.

Also, a three-part progress report on Assignment 2—Collaborate with AISI Technical Subcommittee on Rail and Joint Bars in Research and Other Matters of Mutual Interest, was published in Bulletin 641. Part 1 covers our committee visit to the CF&I Steel Corporation rail-producing facilities and the Department of Transportation High Speed Ground Test Center at Pueblo, Colo., last May. Part 2 deals with the study on the possibility of obtaining rails longer than 39 feet.' Part 3 covers the meeting of the AREA–AISI Joint Contact Committee held in Atlanta last October. Assignment 2 will be continued this year.

A final report was published on Assignment 3—Rail Failure Statistics.

We do not have a report on Assignment 4—Rail End Batter; Causes and Remedies, but this assignment has been retitled to read: "Up-date Data on Methods and Equipment for Making Welding Repairs to Rail and Turnouts" and will be progressed this year.

Assignment 5—Rail Chemistry, is being combined with Assignment 8—Causes of Shelly Spots and Head Checks in Rail and Methods for Their Prevention, into a single assignment titled Rail Research and Development, and will be progressed this year.

The Bulletin contains a progress report on Assignment 6—Joint Bars; Design, Specifications, Service Tests, Including Insulated Joints and Compromise Joints, and this assignment will be continued this year.

We also have a final report on Assignment 7—Metallurgical Effect of Rail Cropping Methods, and a progress report on Assignment 9—Standardization of Rail Sections. This latter assignment will be continued this year.

While we do not have a report on Assignment 10—Effect of Heavy Wheel Loads on Rail, this assignment remains active and will be progressed this year.

I strongly urge all of you whose responsibilities involve rail to review our report.

Committee 5—Track

Remarks by Chairman L. A. PELTON
Superintendent, Track & Structures, Port Authority Trans-Hudson Corporation

The annual report of Committee 5 is published in Bulletin 641, January–February 1973, pages 311–316.

During the past year, your committee held two meetings. Our regular May meeting was held in Atlanta, Ga., and included field trips to the Southern Wood Preserving Plant and to the panel track and turnout assembly plant of the Southern Railway. Your committee wishes to express special appreciation to Rush Kelso and the Southern Railway for their gracious hospitality and their assistance in making this a very informative and educational meeting. Our second meeting was a one-day meeting held in conjunction with the annual convention of the Roadmasters' and Bridge and Building Associations in September.

Three of our subcommittees, Subcommittee B—Revision of Manual (A. J. Schavet, engineer track design, Chicago & North Western Transportation Company, chairman); Subcommittee 7—Track Maintenance (T. C. Netherton, chief engineer, Pittsburgh & Lake Erie Railroad, chairman); and Subcommittee 8—Criteria for Track Geometry Design as Related to Modern Equipment (A. B. Hillman, Jr., chief engineer, Belt Railway of Chicago, chairman) had no reports for publication this year but are continuing work on their assignments.

Subcommittee 2—Track Tools (S. W. George, engineer track, Western Maryland Railway, chairman), is currently devoting their efforts toward review of several of our present tools, the manufacturing tolerances for tools, and the possible need for more insulated tools with the recent expansion of electrified rapid transit systems.

Subcommittee 3—Revision of Portfolio of Trackwork Plans and Specifications (R. E. Kuston, engineer track design, Atchison, Topeka & Santa Fe Railway, chairman), is presently reviewing the whole of the Portfolio to determine the scope and direction to be taken in a possible thorough updating.

R. N. Schmidt, engineer track, St. Louis–San Francisco Railway, chairman of Subcommittee 4—Track Design, recently resigned and his replacement has not yet been named. This subcommittee is reviewing its assignments to determine the necessary action which has to be taken for progress on each one. Present assignments of most significant interest are (1) evaluation of various-cant tie plates, (2) hold-down fasteners for concrete ties and (3) direct fixation fasteners.

Effective March 1, 1973, C. J. McConaughy, track designer, Southern Pacific Transportation Company, retired from active service and as chairman of Subcommittee 5—Turnout and Crossing Design. Mr. McConaughy has been chairman of this very active and important subcommittee since 1960. Under his direction for these many years, Mr. McConaughy and his subcommittee have pursued many time-consuming design problems to come up with much useful data and criteria in many areas of turnout and crossing design. We on Committee 5 are going to miss his fervor and enthusiasm for committee work, and we all wish him many years of happy retirement.

New plans covering manganese steel insert frogs in the 90°–45° angle range; and design criteria for railbound manganese steel frogs were published in Bulletin 640 for approval by the Board of Direction. Current active assignments include

(1) collection and evaluation of information on types of crossing frogs in use as related primarily to speed, tonnage, and frog angle, (2) guard rail taper on crossing frogs, and (3) the redesign of railbound manganese steel frogs to eliminate reverse bends in wing rails and heel rails.

Subcommittee 6—Track Construction (G. E. Fischer, roadmaster, Union Railroad, chairman) published in Bulletin 641 a summary of answers received to a questionnaire on use of panel tracks and panel turnouts. The questionnaire was fairly comprehensive and could be used by any road re-evaluating its policy toward paneling.

Committee 5 notes with particular regret the passing of John S. Parsons, retired chief engineer, Erie Lackawanna Railway. John Parsons is remembered by Track Committee members for his active participation and contribution to this committee work for many years before transferring his membership to the Rail Committee.

A memoir in honor of another Committee 5 member, George Perko, follows.

George Perko
1928-1973

George Perko, born February 22, 1928, to Andrew and Mary Perko at Lansford, Pa., died on March 21, 1973, at Dayton, Ohio, at the age of 45.

Mr. Perko began his higher education at Sampson College, Geneva, N. Y. and completed the requirements for a Bachelor of Science Degree in Civil Engineering at Pennsylvania State College (now University) at State College, Pa. in 1951. While at Pennsylvania State College, Mr. Perko was elected to Chi Epsilon, an honorary society.

Mr. Perko began his railroad career with the Baltimore & Ohio Railroad (now part of the Chessie System) at Baltimore, Md. in 1951. At Baltimore, he worked in various engineering capacities prior to and after completing a technical training program. He was appointed assistant division engineer at East Salamanca, N. Y. in 1955; at Wheeling, W. Va. in 1956; and at Grafton, W. Va. in 1958; assistant trainmaster at Parkersburg, W. Va. in 1961; trainmaster at Pittsburgh, Pa. in 1962; and became division engineer of the Toledo–Indianapolis Division with headquarters at Dayton, Ohio on June 15, 1963, which position he held at the time of his death.

Mr. Perko became a member of the American Railway Engineering Association in 1956, and served as a member of Committee 5—Track, from 1965 until the time of his death. He was also a member of the National Defense Executive Reserve and the Elks.

Prior to attending college, Mr. Perko served in the U. S. Army Artillery.

Surviving Mr. Perko are his wife, Mildred; and his sons, George Perko, Jr., Kenneth Lawrence Perko and David Rand Perko.

Committee 6—Buildings

Remarks by Chairman D. A. BESSEY*
Assistant Architect
Chicago, Milwaukee, St. Paul & Pacific Railroad

For the last three years your Committee 6 has devoted a considerable amount of time to three major subjects—(1) TOFC/COFC Facilities, (2) Spot Car Repair Shop Design, and (3) Diesel Shop Design. The work on TOFC/COFC facilities was completed prior to the convention last year and the report has since been approved for inclusion in the Manual and will become Part 5 of Chapter 6.

The work on spot car repair shop design was also completed before the convention last year and the report has also been approved for inclusion in the Manual and will become Part 3 of Chapter 6.

Extensive research was carried out by Subcommittee 3—Diesel Shop Design (A. R. Gualtieri, chairman), and a substantial amount of time at three committee meetings has been devoted to developing the material for this subject. The original Manual material on diesel shop design was inserted in the Manual in 1955. This has been a widely used section of Chapter 6, with the design criteria and general information being used by the railroad industry as well as engineering firms and other industries outside the railroad.

This material being prepared by Subcommittee 3 is based on the original Manual material on diesel shop design; however, it is being substantially updated to include modern-day innovations and to meet the current requirements for diesel shop design. This material will take the place of the present Manual material covering diesel shops and will be quite lengthy. However, it includes all aspects of diesel shop design including equipment and related facilities, automated pulling systems, piping and service facilities, architectural and structural requirements for the building itself, heating and ventilating, lighting, and many other topics. The subject also deals with the problems involving environmental control. The final draft is being prepared and will be sent out for ballot vote this summer.

Subcommittee 8—Portable Pre-Fabricated Buildings (P. W. Peterson, chairman). This subject was completed this year and the report is printed in Bulletin 641. Later this year this material will be forwarded to the committee for ballot vote for inclusion in the Manual.

The following is a brief status report on the balance of Committee 6 assignments:

Subcommittee B—Revision of Manual (W. C. Sturm, chairman). Work is still in progress in reviewing various reports that have previously been submitted for information to determine if material should be upgraded and included in the Manual. One subject that is being considered is pre-fabricated buildings.

Subcommittee 5—In-Floor Conveyor Systems (D. L. Logan, chairman). This report has been completed and will be submitted as information.

Subcommittee 6—Computer Room Design (R. Hale, chairman). The development of this report is just getting underway and it is our thinking at this time that the material developed would possibly be included under Part 2 of Chapter 6, "Design Criteria for Railroad Office Buildings."

* Presented by Vice Chairman F. D. Day in the absence of Mr. Bessey.

A report was written for information by Committee 6 in 1960 which briefly outlined the basic requirements for computer room design. In recent years the construction of computer rooms has drastically changed due primarily to major changes in electric codes requiring a more complex power and signal distribution system. Another major concern is security. Industries today rely to such a great degree on the computer and its operation that any failure would be a minor disaster. All these things affect the modern-day design concept of computer rooms and are being taken into consideration in the preparation of this material.

Subcommittee 7—Pneumatic Tubes (H. R. Helker, chairman). Mr. Helker's committee will be concluding this assignment this year and a report will be submitted for information.

It was determined at our December meeting that the various assignments were being completed and, therefore, we found it necessary to make a request to the Association that two additional subjects be added to the present list of assignments, as follows:

(1) Maintenance of Way Equipment Repair Shops

In reviewing this subject with the committee members we found that most railroads have converted roundhouse stalls or old motor repair shops into makeshift facilities to maintain the sophisticated maintenance of way equipment that is used by most railroads today. This assignment is to produce design criteria for such a facility which would include a building complete with cleaning and painting facilities and an assembly line maintenance and repair operation.

(2) Portable Crew Housing

The concept of portable crew housing facilities is being adopted or considered by many railroads. It is felt that a complete study should be made on the subject as soon as possible as a guide or general information for those faced with these responsibilities.

Not only does this conclude another year of Committee 6 activity, but it also concludes my three years as chairman of Committee 6. The last three years have been enjoyable and very rewarding and it is difficult to find the words to extend my gratitude to the members of the Association who have been responsible for what, I consider, three productive years. In spite of the problems, such as attempting to increase committee membership and encouraging committee attendance at meetings, we feel that much has been accomplished. Many of the above subjects have been developed over the past few years through the usual manner of subcommittee chairmen working with his subcommittee; however, when the subject has been developed on a preliminary basis, it is reviewed by the entire committee in a workshop session. As a result of this approach, the final report is a composite of the thoughts and knowledge of some 20 to 30 people.

I would like specifically to extend my appreciation to F. D. Day, vice chairman of Committee 6, and O. C. Denz, secretary. I would also like to extend my congratulations to Fred Day, who, at the conclusion of this convention, will become the new chairman of Committee 6, and to W. C. Sturm who, at the December meeting, was elected by the committee to fill the position of vice chairman. I wish them every success, and it goes without saying that the membership of Committee 6 will extend to them their complete cooperation.

Committee 8—Concrete Structures and Foundations

Remarks by Chairman F. A. KEMPE
Regional Engineer, Burlington Northern, Inc.

Our committee met three times last year and thus produced material both for Manual revision and for information. This material is in the last two issues of the Bulletin.

We are developing more specifications for foundation engineering and for lightweight structural concrete for railway bridges.

Any of you not now a member of a committee is welcome to join us either as a member or as a guest. Our next meeting is scheduled for early June.

This concludes my term as chairman of Committee 8. The new chairman will be T. L. Fuller, engineer of bridges, Southern Pacific Transportation Company; the new vice chairman, J. W. DeValle, chief engineer bridges, Southern Railway System.

Committee 9—Highways

Remarks by Chairman K. E. WYCKOFF
Director—Public Works Planning
Burlington Northern, Inc.

The annual report of Committee 9—Highways, is published in Bulletin 640, November–December 1972.

The committee will continue work on its various assignments and will review its Chapter of the Manual in the coming year. A number of Manual revisions are contemplated, partially as a result of proposed changes to AAR Bulletin 6—Recommended Practices for New Installations of Railroad–Highway Grade Crossing Protective Devices.

Committee 11—Engineering Records and Property Accounting

Remarks by Chairman C. R. DOLAN
Engineer—Capital Expenditures, Missouri Pacific Railroad

The committee progressed its assignments during the year, and the report for 1972 is published in Bulletin 640, November–December 1972.

Subcommittee 4 has been working on its assignment covering the Development and Use of Responsibility and Functional Reporting as Related to Maintenance of Way and Capital Expenditures. The work is in its final stages and will be completed this year. The report on this assignment will provide useful information for management purposes.

The committee, through an Ad Hoc Committee, is continuing work with the ICC in revising Valuation Orders.

The report of Subcommittee 7—Revision and Interpretation of ICC Accounting Classifications, made mention of the submission of a proposal by the ICC pertaining to increasing the $500 minimum rule applicable to railroad property acquisition, additions and betterments, as covered by Section 2–2 of the Uniform System of Accounts, to $1500. As information, under Order 32153 (Sub. No. 4) with service date of January 23, 1973, the $1500 minimum rule became effective January 1, 1973.

The committee has had a change in its secretary. G. R. Gallagher, assistant to valuation engineer–system, Santa Fe, succeeded John Weisbeeker, formerly of the Union Pacific.

Committee 13—Environmental Engineering

Remarks by Chairman C. F. MUELDER
Engineer Environmental Control
Burlington Northern, Inc.

Committee 13—Environmental Engineering, is a growing committee. It is increasingly playing a more important part in AREA technical committee work. The environmental thrusts to which we are being subjected in all fields of railroad activities, inject our committee responsibilities into almost all Association activities. At the present, our committee is struggling against time deadlines and current existing need to provide railroad people with recommended practices in the more demanding areas. As you are aware, we are now about five years down the line in regulatory requirements for water pollution control. This was the first ecological thrust. It was closely followed by solid waste disposal and ground pollution. In the last two years, the programs of air pollution have been developed and are now being promulgated. At the present time, we are now witnessing development and proposals for regulations of sound emissions, commonly called noise pollution.

It has been the recommended policy of Committee 13 to devote its effort to the preparation of Chapter 13 in the AREA Manual for Railway Engineering, so that our people would have something to work with in the hour of their need. We must now develop additional information and data in our other assigned areas. However, we just can't seem to do this fast enough to keep up with the rapidly expanding ecology programs.

An area in which our committee needs to become more active involves collaboration with other AREA technical committees, to assist them in providing information for their respective chapters relating to environmental requirements. At this point in time, we cannot properly function in this area as we should. However, I request that other committees refer to us for comments, new materials and revisions as they develop.

Committee 13 membership now consists of 49 members from 22 railroads. Forty of these are active participants. We have 6 associate members, 1 editor, and 1 retired professor. This last year, your committee implemented the association policy of weeding out inactive members. We are continuing the program this year.

We greatly need more active members to carry out our assignment demands.

We have seven permanent assignments for investigation and report:

1. Water Pollution Control
2. Air Pollution Control
3. Land Pollution Control

4. Industrial Hygiene
5. Plant Utilities
6. Corrosion Control
7. Noise Pollution Control

Since re-organization of the committee, our function has been primarily devoted to the development of Chapter 13 in our Manual.

Part 1—Water Pollution Control, has been devoted to the development of typical equipment and processes, applicable to railroad operations and situations which would meet the existing demands upon our industry for the removal of oily wastes from our sewerage system. With this there was developed recommended practices and needs for sampling, instrumentation and testing of the effluent waters. We also assisted our membership to determine regulatory requirements, by developing a directory of governmental water pollution control agencies. This year, a report was developed on regulatory requirements for certification of waste water treatment operators. Many new technological words, abbreviations, etc., have been coined. The committee is presently developing a glossary of definitions related to the assignment, for eventual insertion into the Manual.

Part 2—Air Pollution Control, has been devoted to the development of guide standards, sampling techniques and a directory of governmental enforcement agencies. This year, a report was developed on the operation of incinerators with emphasis on particulate emissions to the atmosphere.

Part 3—Land Pollution Control, has been devoted to the development of proper procedures and regulatory requirements for the operations of a sanitary land fill. This year, a report was developed on the disposal of toxic wastes. This includes material on accidental spills from derailments and something on contingency plans —which, of course, may involve water and air pollution as well as land pollution.

Part 4—Industrial Hygiene, is a carry-over assignment of responsibilities from our old water service committee functions. However, in today's world we still have with us certain railroad hygienic problems. The problems of toilet disposal along railroad right-of-way has been projected into the environmental picture. This year, the committee presented a report on toilet facilities, with data and information on different types of equipment designed to meet the criticisms of disposal of raw sanitary sewerage.

Part 5—Plant Utilities, is also a carry-over assignment of responsibilities from our old committee functions. Generally speaking, the same railroad personnel involved in environmental work are involved in other railroad plant utilities and facilities involving hydraulics, pumping and storage facilities of liquids and gases. This year, the committee completed a study on the design of high-speed fueling facilities for locomotives.

Part 6—Corrosion Control. This year the committee concluded its assignment on the study of corrosion control in diesel engine cooling water. This is a final report.

Part 7—Noise Pollution Control, is a new assignment this year. Regulations for the control of sound emissions are now being formulated and promulgated. We are at the beginnings of regulatory actions on railroad properties. The committee has developed information as it relates to regulations and codes, noting the requirements of OSHA standards. We note that this area of environmental control is very insidious and may be the most costly to our industry. It is also the area in which most railroads have little or no technical skills.

Your committee has held three meetings this year:

Meeting No. 1—Organizational in nature held March 6, 1972, 9:00 am—12:30 pm at the Sherman Hotel, Chicago in conjunction with the annual convention.

Meeting No. 2—Business meeting held May 23, 1972—9:00 am—4:00 pm, Pick–Congress Hotel, Chicago; speaker at our luncheon was Dr. Edward H. Bryan, manager ecology, Division of Rex Chain Belt; topic, Business Aspects of Ecology as It Affects Railroading.

Meeting No. 3—Business meeting and field trip, August 21, 22, 1972, held at the Sheraton–Gibson Hotel, Cincinnati, Ohio. Field trip to Armco Steel Company plant at Middletown, Ohio. Inspected waste oil collector pans designed for fuel oil spillage at locomotive fueling site. Inspected their equipment and facilities for waste oil removal at their treatment plant. Inspected their research and development laboratory.

This coming year we will continue to develop the much needed Manual materials of recommended practices in our assigned areas of responsibilities.

Committee 14—Yards and Terminals

Remarks by Chairman G. H. CHABOT
Engineer Contracts, Chessie System

Since the last Convention Committee 14 has had a most active year. It met for two-day meetings at Nashville, Tenn., in June and at Erie, Pa., in October; field trips were made in conjunction with the meetings. In June, we visited the L&N rail welding plant at Radnor Yard and in October, the coal and iron ore unloading, storage, and reclaiming facilities of the Pittsburg and Conneaut Dock Company at Conneaut, Ohio.

The basic report of your committee's activities is contained in Bulletin 640, page 207. Individual reports may be found in Bulletins 639 and 640. Six subjects were assigned; five reports were completed; four were prepared as information with the recommendation that they be discontinued; and the other was recommended as Manual material.

The reports submitted as information include:

1. An outline of the various equipment and methods utilized in the modernization of classification yards.
2. Tabulations of freight car lengths to determine track capacities in the design of yards. The weighted average length of all cars is 50 ft 5 in.
3. An overall review of facilities needed at urban mass transportation terminals. This report supplements data contained in the Manual on this subject.
4. A description of the various types and systems of lighting used in yards and terminals.

The fifth report, on Scales, submitted as Manual material, probably caused more disagreement, concern and reaction than any other subject in the entire history of the Association. The Scales Subcommittee was charged to develop specifications for the testing of railway scale systems used for weighing in motion. No one really realized the controversial nature of the subject until the first report for Manual material was submitted. Then we had a big problem, a real challenge. A second report, an outcrop of the first report, was prepared, submitted, and published in Bulletin 640, page 150. The revised report was a coordinated effort of representatives of the Association Board of Direction meeting with the Scales Subcommittee on October 1, 1972, at Erie, Pa. The reception of this report was worse, especially from interested parties outside of the railroad industry. At the invitation of the Board of Direction the subcommittee met with the Directors for a joint analysis and review of the problem; the report was again revised.

Well, after seven or eight meetings, and perhaps more (incidentally we were second only in the number of meetings to the Kissinger–Le Doc Tho peace talks) and after three reports, we hopefully believe that the last redraft will fulfill the requirements of the railroad industry, of the scale manufacturers and of certain state regulatory, inspection and enforcement bodies. (I hope, I've made myself clear and haven't lost you by now. If I did, I wouldn't blame you anyhow.) Finally, representatives of AREA Board of Direction, of the Engineering Division General Committee and of Committee 14 (Scales Subcommittee), about 20 in all, attended on January 30, 1973 the interim meeting of the Committee on Specifications and Tolerances, National Conference on Weights and Measures, to present a united front for the acceptance of the last revised specifications concerning the testing of scales used in motion weighing by the railroad industry. No official action has been publicized yet, but it appears that the S&T Committee will act favorably and recommend that the "Specs" be made a part of the National Bureau of Standards Handbook 44.

If the Scales Subcommittee members would have known what was hanging over their heads, they certainly would not have tackled the revision of the Manual, Part 5, Scales, Chapter 14. I must report today that the 122 pages have been reviewed and condensed to about 40 pages. The required number of votes has been received, none negative or objecting and, therefore, the report will be submitted shortly for adoption in the Manual. I think that Subcommittee Chairman Fred Day (PCT) and the 20 subcommittee members should be complimented for a terrific job well done; I have never seen a group put so much effort to accomplish a job as these men did last year.

During the coming year the committee will study and report on:

1. The effects of approach grades and vertical curves on hump gradient design. The intent is to update Manual material on this subject.
2. Security and protective measures against theft, vandalism, etc., in yards and terminals.
3. Car rollability as a criterium in the design of classification yards.
4. New applications of computers in classification yards.
5. Trends in intermodal facilities.
6. Best location of scales used in railroad service.

The committee is presently reviewing Parts 1 through 4 of Manual Chapter 14 and anticipates completion of this work in time for publication in the 1973 November–December Bulletin.

Committee 15—Steel Structures

Remarks by Chairman M. L. KOEHLER
Engineer Structures
Penn Central Transportation Company

The Manual recommendations of Committee 15 as published in Bulletin 640, pages 132 through 137, cover revisions to the section of Part 3 dealing with fabrication requirements of riveted and bolted construction; also a complete revision of the section on dimensional tolerances for structural members.

The Subcommittee on Welded Steel Railway Bridges is currently reviewing the latest specification changes in the American Welding Society Welding Code as related to railway bridges.

The Manual revisions submitted for adoption during the past year are the results of the committee's continuing efforts to maintain a complete and up-to-date specification for steel structures.

The purpose of Committee 15 is to formulate specific and detailed rules for the design, fabrication and erection of steel structures and to recommend procedures for the maintenance, inspection and rating of existing iron and steel railway bridges.

Committee 15 solicits your suggestions for future assignments and would appreciate that they be furnished in writing, addressed to the chairman.

This concludes the report of Committee 15 and my term as chairman of the Committee. The new chairman is current Vice Chairman L. F. Currier, engineer structures, Louisville & Nashville Railroad, and the new vice chairman is D. S. Bechly, assistant chief engineer structures, Illinois Central Gulf Railroad.

Committee 16—Economics of Plant, Equipment and Operations

Remarks by Chairman W. G. BYERS
Bridge Engineer, Western Lines
Atchison, Topeka & Santa Fe Railway

Subcommittee B, under the direction of George Rugge, has been in the process of completely rewriting Chapter 16 of the AREA Manual for the past several years. Emphasis during the past year has been on preparation of Part 4—Operations, and Part 6—Industrial Engineering.

Subcommittee 1 under the direction of J. C. Martin completed its assignment to study optimum length, speed and weight of freight trains under varying traffic and competitive and operating conditions relating to (a) balanced trains, (b) long train operation and (c) short train operation. Its final report is published in Bulletin 639, September–October 1972.

Subcommittee 2—Engineering methods and economic considerations involved in quality of transportation service, M. B. Miller, chairman; Subcommittee 3—Determination of factors, including various traffic volumes, affecting maintenance-of-way expense, and the effect of using such factors, in terms of equated mileage or other derived factors, for allocation of available funds to maintenance-of-way, collaborating as necessary or desirable with Committees 11 and 22, T. C. Nordquist, chairman; Subcommittee 4—Economic evaluation of methods for reducing the probability of derailments, R. P. Hoffman, chairman; Subcommittee 5—Economics of freight cars with characteristics approaching the limits of accepted designs, D. H. Noble, chairman; and Subcommittee 6—Factors involved in rationalization of railway systems, T. D. Kern, chairman, all made varying amounts of progress on their assignments during the year but did not publish reports.

Subcommittee 7—Application of industrial engineering functions in the railroad industry, R. D. Penhallegon, chairman, worked with subcommittee B in preparing Manual material and is now in the process of making a survey of standards applications in the railroad industry.

Subcommittee 8—Economics of systems for control of train operations, G. R. Janosko, chairman, is beginning work on its assignment, which was new last year.

Last July, R. L. Millner, a former chairman of the committee, and C. W. Sooby, who served as secretary of the committee for 14 years, were elected Members Emeritus.

Mr. Sooby died on September 6, 1972, and a memoir prepared by George Rugge is presented below. Although Clarence Sooby was widely known as an authority on the design of traffic control systems and will be remembered by Committee 16 members as a dedicated secretary and formidable poker player, I personally will remember him for his ability to make a new member of the committee feel at ease and welcome.

H. J. Kay recently found it necessary to resign as vice chairman of the committee and M. B. Miller has been approved as the new vice chairman.

Clarence W. Sooby
1901-1972

Clarence W. Sooby, retired manager of management information systems, Union Switch & Signal Division, Westinghouse Air Brake Company, died on September 6, 1972, at Pittsburgh, Pa., where he had resided prior to and subsequent to his retirement. He is survived by his wife, Helen; a son, Clarence, Jr.; and a daughter, Carol.

Mr. Sooby was born at McPherson, Kan., on May 7, 1901, and was educated in the public schools of Kansas City. His education included a business course at Polytechnic High School. He began his railroad career in 1922 with the Kansas City Southern, and held various positions in the operating department including that of division superintendent at Shreveport, La. He also handled special assignments for the executive vice president. During 1943 he worked for the Office of Defense Transportation. He joined Union Switch & Signal in 1944 and served with that company until his retirement in 1966.

He was known and respected throughout the railroad industry as an outstanding analyst for centralized traffic control signaling, and was a pioneer in analyzing and developing automated hump yards. His reputation was international in scope. After his retirement, he became an international consultant in signal systems and classification yard automation.

Mr. Sooby joined American Railway Engineering Association in 1949, becoming a member of Committee 16 at the same time. He served as secretary of Committee 16 from 1952 until 1967. During his years as secretary, the committee made great strides forward, no small part of which was due to his executive ability in furnishing the basic management for the committee. Following his retirement as secretary, he was active in committee affairs and assisted in Manual revisions and planning of other activities of the committee. He was elected Member Emeritus of Committee 16 on May 20, 1972.

His human approach to some of the most complex analytical problems in the railroad industry earned him the respect of all those who came in contact with him. His associates' lives have been enriched by his great grasp of railroad operations.

Committee 25—Waterways and Harbors

Remarks by Chairman L. H. McCURRY
Assistant Engineer, Atchison, Topeka & Santa Fe Railway

The report of Committee 25—Waterways and Harbors, is published in Bulletin 641, pages 233 through 273, January–February 1973. Its report relates the progress made in the work that was briefly discussed in last year's convention report.

As you will note in the report published in Bulletin 641, Committee 25 has submitted as information the complete statement of the Association of American Railroads that was presented to the United States Water Resources Council on the Council's proposed "Principles and Standards for Planning Water and Related Land Resources." In addition, the report includes three subcommittee progress reports on drafts of a proposed complete Manual revision.

The published subcommittee progress reports have been the responsibility of:

R. L. Bostian, chairman of Subcommittee B, who submitted as information a draft of the Table of Contents. His committee was responsible for coordinating all work on the proposed Manual revision.

John Gressitt, past chairman, and the late S. G. Wintoniak, chairman of Subcommittee 2, who submitted as information drafts of terminology of Part 1 and Part 10 of the proposed Manual revision.

R. C. Rankin, chairman of Subcommittee 3, who submitted as information a draft of terminology of Part 2 of the proposed Manual revision.

J. C. Fenno, past chairman, and E. C. Lawson, present chairman of Subcommittee 6, who submitted as information drafts of Parts 3, 4 and 6 of the proposed Manual revision.

E. S. Laws, chairman of Subcommittee 7, is working on drafts of terminology for Parts 7, 8 and 9.

A. C. Parker, vice chairman, and R. V. Gilbert, secretary, have been quite active in progressing the business of Committee 25.

As was announced in the AREA News this past year, Committee 25 has honored two of its members, J. F. Piper, Penn Central, and G. R. Collier, Santa Fe, by voting them to Member Emeritus for their meritorious service to the committee and to the Association.

Committee 25 held two business meetings during this past year, the last one being held on March 18, 1973. For the coming year Committee 25 had plans to continue work on the proposed Manual revision. In addition to the Manual revision work, Committee 25 had planned to review the 1,122 page report of the National Water Commission.

Committee 25, in Bulletin 631, reported on the formulation of the National Water Commission and the review of the NWC report would have been a continuation of Committee 25's information report on the subject. The NWC report generally recommends the end to federal irrigation construction, cancellation of old but unused water project authorizations and free-market pricing of water. To those of you that have an interest in water policy, and I'm sure that most of you have in some manner, you are aware of the adverse and tremendous storm of protest that the political and/or water oriented groups have made publicly and at the four NWC public meetings held in Spokane, Wash., on January 8 and 9; Phoenix, Ariz., on January 11 and 12; New Orleans, La., on February 5 and 6; and Washington, D.C., on February 8 and 9, all of this year.

It is with sincere regret that this report includes the unfortunate news that one of our respected members passed away. S. G. Wintoniak, staff engineer, Penn Central Transportation Company, and chairman of Subcommittee 2, passed away on Sunday, March 18, 1973, as a result of a passenger train derailment. The train was enroute to Chicago where Mr. Wintoniak was to attend a Committee 25 meeting and this Convention. We extend our most sincere sympathy to the family and friends of Mr. Wintoniak. He will be truly missed by all his associates because of his character, humility and dedication.

As was reported to you in the opening session of this convention by E. W. Hodgkins, executive manager, the Board of Direction at their meeting on Saturday, March 17, 1973, voted to abolish Committee 25—Waterways and Harbors. With this action, Committee 25 will be abolished effective at the close of this convention and this report is the concluding and final report of the committee. As chairman, I would like to express my sincere appreciation to all those that have assisted in carrying out the activities of Committee 25. I received my gavel of office as chairman when A. L. Sams, past chairman of Committee 25, was the in-coming president of this Association. D. V. Sartore, now the in-coming president, was also a member of Committee 25; thus, I end my duties with a feeling of close association, and I predict that the activities of Committee 25 will be continued in some manner because of its unique relationship with the railroad industry.

Committee 27—Maintenance of Way Work Equipment

Remarks by Chairman C. R. TURNER
Superintendent Work Equipment
Denver & Rio Grande Western Railroad

Under Assignment 1—Improvements to Be Made to Existing Work Equipment, the entire committee membership feeds information to the subcommittee chairman for handling major machine problems with the manufacturers. This assignment is a continuous one and is a very worthwhile endeavor.

Assignment 2—Machine Design: The "wheels and axles" segment of this assignment has been completed with the development of Manual material. The committee is now working on details of hydraulic system requirements for roadway machines. The end result of this task will be much improved design criteria for machines, resulting in greater dependability, improved performance and lower machine costs to the railroad industry. We should finalize this segment this year.

The committee has no reports this year on current Assignments 3—Rail Heaters and Coolers for Laying Continuous Welded Rail, 4—Actual Cost to Operate a Piece of Work Equipment, 5—Proposed Minimum Information About Machines for Manufacturers to Give in Advertising Fliers and Brochures, and 6—Study Utilization of Cars Used by Maintenance of Way Departments. However, a report on Assignment 5 is now being edited and will be completed this year.

Among the subjects contemplated for the future are: (1) The effect of health, welfare and ecology information on the design and construction of roadway equipment, and (2) Equipment for bonding of track components.

This completes my term as chairman of Committee 27. The new chairman is the current vice chairman, F. H. Smith, assistant engineer, Atchison, Topeka & Santa Fe Railway. The new vice chairman is the current secretary of the committee, C. H. Olds, superintendent of maintenance of way work equipment and welding, Reading Company.

Committee 28—Clearances

Remarks by Chairman M. E. DUST
Assistant Bridge Engineer
Louisville & Nashville Railroad

The report of Committee 28—Clearances, appears in Bulletin 640, November–December 1972.

The Board of Direction has authorized the combining of current Assignments 3 and 7 into a single assignment reading: "Investigate New Methods and Development of Equipment for Recording Measurements of Clearances of Structures along Right-of-Way and Overall Dimensions of Cars and Loads." Over the past few years several promising ideas for devices to obtain dimensions of high and wide shipments and clearances of obstructions along the right-of-way have been brought to our attention but were subsequently dropped.

A new subcommittee has been set up in our committee to revise the "Suggested Method of Presenting Published Clearances" now in Chapter 28 of the Manual. This group will be under the chairmanship of F. A. Svec.

Several of our subcommittees have arrived at the point in their work where the cooperation and assistance of certain AAR organizations is being sought to bring the work to completion. Two other subcommittees have active assignments and will present reports on them this year.

We plan to hold our fall meeting this year in St. Louis. It will be a joint meeting with the board of directors of the Railway Industrial Clearance Association. It is the consensus that a joint meeting would be beneficial to both organizations.

Committee 32—Systems Engineering

Remarks by Chairman H. L. CHAMBERLAIN
Engineer of Structures
Missouri Pacific Railroad

Over the past year, Committee 32 has concerned itself with a complete review of its assignments as they pertain to the abilities of the committee and the desires of the Association.

After much study and discussion with the subcommittee chairmen and various other concerned members of the committee, the standing assignments were redrafted and the committee reorganized around the revised assignments.

The realms of computer science and systems engineering are two of the most rapidly developing in our technological society. For example, the mini-computer has opened new and wider horizons which were almost undreamed of only a few years ago. The programmable calculator now has speed and capacity which are astonishing, rivaling the small computers in their wealth of applications.

Because of the constantly changing scene, the thrust of the committee's effort will be directed towards documenting and reporting of systems development within the railway industry. The committee feels that it can best serve the Association in this manner.

The new committee assignments have been published in Bulletin No. 641 for January–February 1973. Although the general assignments remain broad in scope, it will be noted that they are broken down into segments, or subtopics, for investigation and report. As they are reported they will be replaced by other topics as desirable or necessary.

Ground Rules for Discussion Section

Comments on the reports and papers published in the four technical issues of the AREA Bulletin, by either members or non-members, are invited. These comments will be printed in a special discussion section located in the back of the Bulletin and in accordance with the procedures outlined below. The purpose of the section is to stimulate greater interest in the published reports and papers and to offer to those not involved in their preparation the opportunity to present their thoughts on the different subjects, whether pro or con, based on their knowledge and experience.

For the information and guidance of all concerned, here are the ground rules adopted by the Board of Direction for handling and publishing comments on AREA published papers and reports:

- Letter containing comments must be addressed to executive manager, be received by the deadline published with paper, contain identification number of paper or report, and be identified with writer's signature, typed or printed name, title, company and full address, including zip code.

- Reader's comments will be forwarded to author or appropriate committee for further comments or rebuttal.

- Both reader's comments and author's reply will be published at the same time and in the earliest Bulletin having space available.

- All comments must be in good taste, add to discussion on the subject of paper or report, and be constructive in nature.

- Board Committee on Publications will be the review or mediation group should some problem or something questionable arise.

- After deadline, no further comments on a particular paper or report will be accepted for publication, unless extenuating circumstances exist.

Identification number of papers open to discussion will be located near the title and must be used in comments to positively identify the paper to which they refer. Comments on committee reports should refer to the proper committee and assignment numbers.

Deadline for comments will be given in a footnote on the first page of the paper or committee report, the latter covering all of the subcommittee reports of that particular committee. In general, this deadline will be approximately 90 days after date of issue. However, this will vary to some extent because the intervals between issues of the *Bulletin* are not constant throughout the Association's publication year, which extends from September to July, inclusive.

The Board of Direction feels that, with the cooperation and interest of all concerned, discussions on papers and reports published by the Association should prove to be both stimulating and informative.

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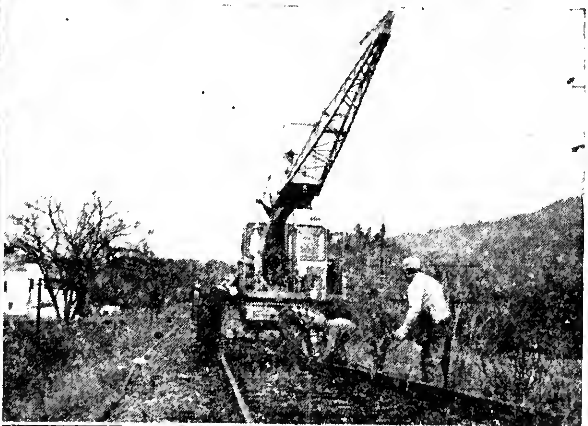

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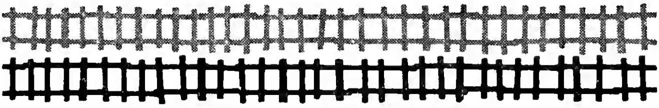

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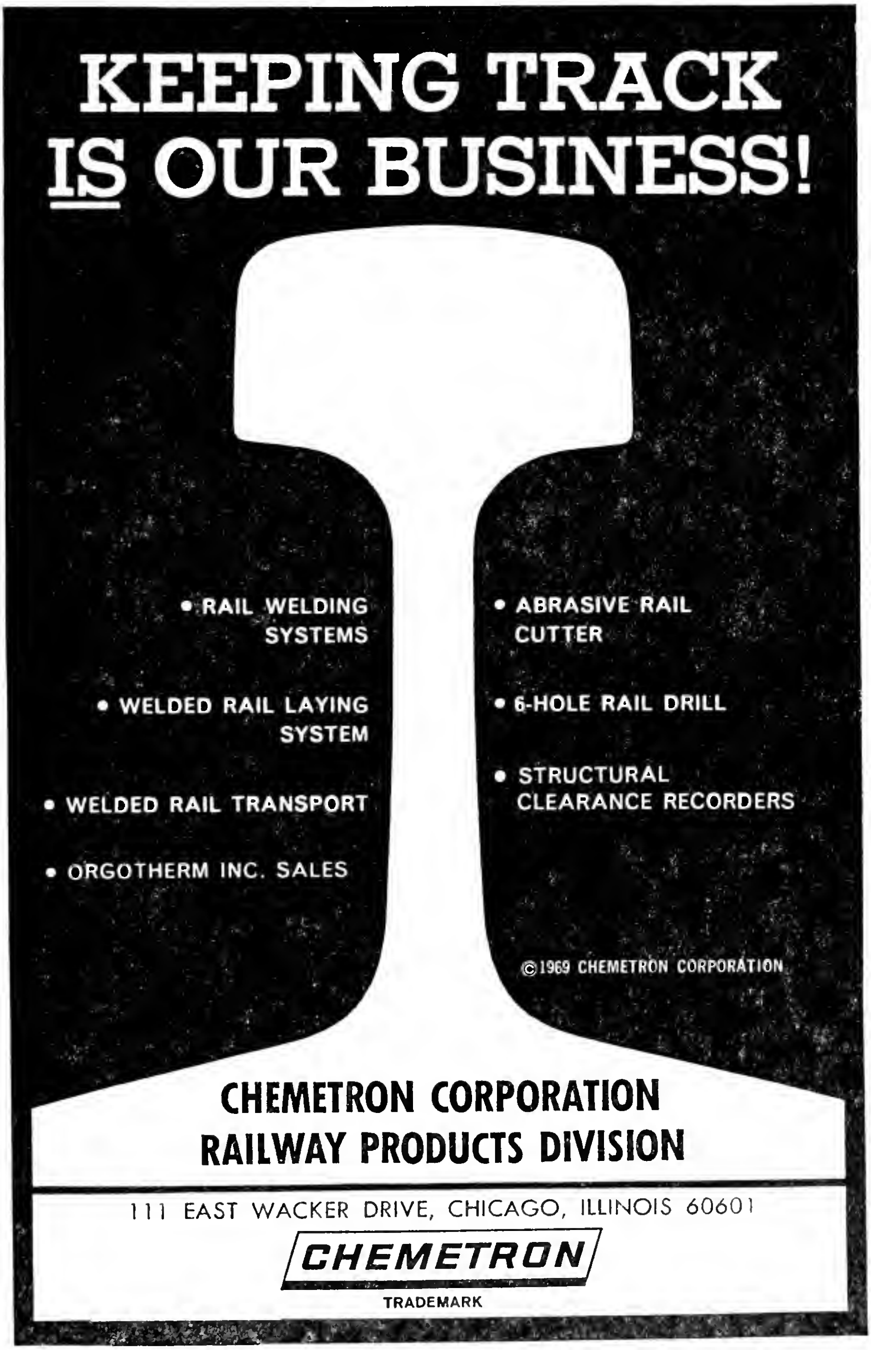
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REPORT OF EXECUTIVE MANAGER

Report of the Executive Manager

March 21, 1973

To the Members:

The 1972 Association year was a success from most aspects. One of the bright lights is the level of AREA membership. Last year I reported a decline in membership—a loss of 77 members compared with the year before. In 1972, however, the statistics show a gain of 88 members, a remarkable showing in view of the decline in the number of railroad employes that are interested in and eligible for membership in the AREA. Another bright aspect of the 1972 operations is a strengthening of the Association's financial situation. Receipts exceeded disbursements by $2,673, even though a deficit of some $4,010 was anticipated, reflecting continued high publication sales, increased advertising receipts due to the efforts of the Special Board Committee on Advertising, and close control of expenditures at Association Headquarters.

The AREA operational year began on March 9, 1972, at the end of that year's Annual Meeting and ended on March 21, 1973, at the end of the 1973 Annual Meeting; the AREA fiscal year coincides with the calendar year.

Your officers and directors are hard-working and dedicated men who spend many hours furthering the interests of the Association and the industry they serve. Furthermore, they do not hesitate to make revolutionary decisions when investigation and analysis have proven that such is necessary or desirable to keep the Association on a forward, dynamic course.

Over the past few years the need to consolidate and streamline our technical committees to keep up with the changing conditions in the railroad industry and within the AREA has been recognized by the Board of Direction and has been the subject of much study and discussion. In 1972 the Board, electing to implement some of the changes that have been under study, eliminated Committee 20—Contract Forms, Committee 25—Waterways and Harbors, and Committee 30—Impact and Bridge Stresses, effective with the close of the 1973 Annual Meeting. It also reactivated a committee to work in the field of railway electrification and other electrical fields relating to the fixed properties of the railroads. The new committee will be known as the Committee on Electrical Energy Utilization. The Board also voted to merge Committee 31—Continuous Welded Rail, into Committee 4—Rail, effective on March 20, 1974.

Major Meetings During 1972 Association Year

The Eighth Regional Meeting of the Association was held at Atlanta, Ga., on October 26, 1972. It was attended by 420 AREA members and guests, the highest attendance so far attained at a Regional Meeting. The meeting was planned and directed by AREA Director R. A. Kelso, chief engineer, line maintenance, Southern Railway System. One of the features of the meeting was an address by L. Stanley Crane, the Southern's executive vice president of operations.

The 72nd Annual Meeting of the AREA and the 1973 Annual Meeting of the Engineering Division, Association of American Railroads was held on March 19–21, 1973, at the Palmer House, Chicago. Total registration was 951, comprised of 500 railroad members and guests and 451 non-railroad members and guests.

COMMITTEES OF THE 1972 BOARD OF DIRECTION

Executive

R. M. Brown *(Chairman)*, D. V. Sartore, R. F. Bush, E. Q. Johnson, A. L. Sams

Membership

D. V. Sartore *(Chairman)*, E. Q. Johnson, L. A. Durham, John Fox, C. E. Weller

Finance

B. J. Worley *(Chairman)*, R. F. Bush, E. Q. Johnson, W. J. Jones, B. G. Anderson

Research

A. L. Sams *(Chairman)*, W. S. Autrey, R. A. Kelso, A. B. Hillman, B. J. Gordon

Publications (Special)
(Manual and Publications)

W. S. Autrey *(Chairman)*, J. T. Ward, J. T. Collinson, W. J. Jones, C. E. Weller

Technical Activity (Special)
(Assignments and Personnel)

J. T. Ward *(Chairman)*, D. V. Sartore, R. F. Bush, A. L. Sams, W. S. Autrey

Regional Meetings (Special)

R. A. Kelso *(Chairman)*, J. T. Ward, J. T. Collinson, John Fox, B. J. Gordon

Advertising (Special)

W. J. Jones *(Chairman)*, B. J. Worley, L. A. Durham, A. B. Hillman, B. G. Anderson

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Special features were again emphasized and committee reports limited to brief accounts of accomplishments and future plans without repetition of previously published material. The Engineering Division session again was held on Monday afternoon and consisted of reports on the activities of the division during 1972, one AREA committee report and a number of timely and informative addresses and illustrated talks.

The 1973 meetings were presided over by AREA President and ED Chairman R. M. Brown, chief engineer, Union Pacific Railroad. The address at the Annual Luncheon was given by John C. Kenefick, president of the Union Pacific.

MEMBERSHIP

Membership statistics, established during 1968 on a calendar year basis for administration and comparison, show a gain of 88 during 1972 as compared to a loss of 77 during 1971. All payments received after December 31, 1972, for reinstatement of those dropped for nonpayment of dues during 1972 appear in the January 1973 record. It will be noted that 226 new members were elected during the year and 19 persons were reinstated to membership. Of the 72 members dropped during 1972, 8 were reinstated in 1973 prior to February 28. Also, up to February 28, 1973, there has been a gain of 10 junior members. Fourteen new members and two new associate members have also been elected. On the other hand, 10 members have died and 28 members who were in good standing at the end of 1972 have submitted their resignations. This would reflect a loss of 13 members in the first two months of 1973.

This points out the need for continuing specific efforts on the part of all AREA members to interest their friends and associates both inside the railroad industry and allied to it, in AREA membership. A wide range of people are qualified for AREA membership, and would benefit by it as would the Association. These qualifications are given in Article II, Sections A, B, E and F, of the AREA Constitution (see pages 236–238 of the 1973 Directory Bulletin—Number 642, April–May 1973). Approximately 250 new members are needed each year simply to overcome normal attrition. Your help is earnestly solicited in this vital area of Association efforts. Maintaining a high level of membership will help us to retain the annual dues at their present low level.

Membership

	Membership Years			
	1971		*1972*	
Membership as of January 1		3341		3264
New members during year	134		226	
Reinstatements during year	32		19	
Gain or loss in junior members	+7		+29	
		173		274
Deceased during year	46		37	
Resigned during year	44		82	
Dropped during year	160		72	
		250		186
Net gain or loss	—77		+88	
Membership December 31		3264		3352

Membership Classification by Years

For each of the membership years shown, the year begins on February 1 and ends on January 31 of the following year, except 1968, 1969, 1970, 1971 and 1972. For 1968, the year begins on February 1 and ends December 31. For 1969, 1970, 1971 and 1972, the year begins January 1 and ends December 31.

	1965	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*
Life	457	446	434	433	437	443	451	460
Member	2516	2528	2665	2659	2577	2579	2502	2549
Associate	268	263	265	258	264	257	244	247
Junior	66	65	57	56	55	62	67	96
Totals	3307	3302	3421	3406	3333	3341	3264	3352

Student Affiliates

Not included in the foregoing tabulations are the Student Affiliates enrolled in the Association on college campuses. As to the October 1, 1972–September 30, 1973, academic year, as of February 28 there were 6 students from 4 campuses affiliated with AREA, compared with 11 students from two different campuses as of the end of the previous academic year.

From late 1960, when the Student Affiliate Program started, to February 15, 1972, the Association has enrolled a total of 303 students on 66 different college and university campuses in the United States and Canada.

Deaths During 1972 Association Year

From May 1, 1972, to May 1, 1973, notice was received at Association Headquarters of the deaths of 42 members, 6 more than the previous Association year and 3 fewer than 2 years ago.

One of the deceased was a past president of the Association—**G. W. Miller** (M 39, L '69), president 1954–1955. Mr. Miller died on January 16, 1973, at the age of 67. He had retired as assistant chief engineer of Canadian Pacific Limited in 1969. Two other deceased members were past directors of the Association—**E. E. Mayo** (M '21, L '56), director 1952–1954, and **J. S. Parsons** (M '40, L '69),, director 1964–1966. Mr. Mayo, who retired as vice president, Southern Pacific Pipe Lines, Inc., in 1959, died on November 18, 1972, at the age of 87. Mr. Parsons, who retired as chief engineer of the Erie Lackawanna Railway in 1965, died on August 1, 1972, at the age of 70.

A number of other deceased members are worthy of note, either for the prominent positions they had attained or for the many years they had devoted to AREA committee service. They are:

D. W. Converse (M '26, L '60), retired bridge engineer, Akron, Canton & Youngstown Railroad, member of Committee 6—Buildings, 1946–1963; **B. E. Crumpler** (M '42, L '71), retired assistant chief engineer—construction, Norfolk & Western Railway, member of Committee 5—Track, 1944–1949, Committee 3—Ties and Wood Preservation, 1949–1958, and Committee 14—Yards and Terminals, 1958–1972; **S. F. Grear** (M '20, L '53), retired assistant engineer of bridges, Illinois Central Railroad, member of Committee 7—Timber Structures, 1927 until the time of his death, serving as chairman 1945–1948 and becoming Member Emeritus in 1954, and Committee 30—Impact and Bridge Stresses, 1936–1953; **T. W. Hislop** (M '43, L '69), retired supervisor water service, New York Central System, member of Committee 13—Water, Oil and Sanitation Services (now Environmental Engineering), 1944–1962; **J. T. Hoelzer** (M '44, L '70), retired regional engineer, Baltimore & Ohio Railroad, member of Committee 9—Highways, 1947–1966; **A. E. Laessig**, retired president, Unit Rail Anchor Corporation; **R. L. Mays** (M '38, L '69), retired engineer public improvements and contracts, Norfolk & Western Railway, and formerly chief engineer of the Nickel Plate, member of Committee 8—Concrete Structures and Foundations, 1939–1955, former Committee 29—Waterproofing, 1945–1961, being chairman, 1949–1951, Committee 22—Economics of Railway Construction and Maintenance, 1956–1968, and Committee 9—Highways, 1968–1972; **Crosby Miller** (M '14, L '46), retired chief engineer, Chesapeake & Ohio Railway; **B. H. Moore** (M '45, L '71), retired assistant to vice president, Association of American Railroads, member of Committee 11—Engineering Records and Property Accounting, 1945–1965; **Embert Osland** (M '47, L '72), retired office engineer, Atchison, Topeka & Santa Fe Railway, member of Committee 4—Rail, 1949–1970; **J. W. Smith** (M '33, L '68), retired chairman of the board, Seaboard Coast Line Railroad; **C. W. Sooby** (A '49), retired manager-transportation economics, WABCO, member of Committee 16—Economics of Plant, Equipment and Operations, 1949 until the time of his death, having been elected Member Emeritus in 1972; **K. J. Wagoner** (M '30, L '59), retired chief engineer, Baltimore & Ohio Railroad, member of Committee 8—Masonry (now Concrete Structures and Foundations), 1947–1961.

ACTIVITIES OF TECHNICAL COMMITTEES

Assignments

During 1972 the 22 standing committees of the Association worked on 157 assignments, 13 of which were new. In addition, the Special Committee on Concrete Ties, which was created by the Board of Direction in 1969, continued its study of the new Specifications for Concrete Cross Ties (and Fastenings) which were published in preliminary form for comment and criticism in Bulletin 634, September–October 1971.

Many of the subcommittees held their own meetings before, during or after the scheduled meetings of the full parent committees. At the full committee meetings, the subcommittee chairmen reported on their assignments and discussed any problems with the work with other members of the full committee. This procedure enables the wide knowledge and experience of all the members of AREA committees, from a large number of railroads, to be applied to the studies of the subcommittees.

AREA committee work is directed toward the preparation of reports for information, toward revising material appearing in the AREA Manual for Railway Engineering and the Portfolio of Trackwork Plans, and toward carrying out special projects related to their assignments.

The 1972 statistics show that our 22 standing committees produced one or more information reports on 56 of their 157 assignments (not including Assignment A). In addition, the committees submitted 12 reports containing Manual recommendations, all of which were published in Part 1 of the November–December Bulletin, separate from the committee reports. Furthermore, most committees presented brief status statements with respect to assignments on which they made no formal report.

At its meeting in November 1972, the Board of Direction decided to abolish two standing committees—Committee 20—Contract Forms, and Committee 30—Impact and Bridge Stresses, effective with the conclusion of the March 1973 Convention. In the future existing Committee 20 Manual material will come under the jurisdiction of Committee 11—Engineering Records and Property Accounting, while the work formerly performed by Committee 30 will be taken over by the three remaining structural committees—Committees 7—Timber Structures, 8—Concrete Structures and Foundations, and 15—Steel Structures. Another standing committee —Committee 25—Waterways and Harbors, was abolished effective at the conclusion of the March 1973 Convention by action of the Board of Direction at its meeting on March 17, 1973. At that same meeting the Board authorized the re-establishment of an AREA electrical committee. The new AREA committee will be known as the Committee on Electrical Energy Utilization. In addition, Committee 31—Continuous Welded Rail will be merged into Committee 4—Rail, effective March 20, 1974.

During 1973 the remaining 19 technical committees, plus the one new committee, as a whole will work on 142 assignments, 8 of them new.

Classification of Material

The work of AREA committees during 1972 was so diversified that, as in other years, it is impossible to do other than refer to it in general terms in a report such as this. However, the following is a general categorical classification of the results of this work, as published in the technical Bulletins of the Association.

Recommendations pertaining to the development or revision of 26 different specifications, recommended practices and trackwork plans for inclusion in the AREA Manual and Portfolio of Trackwork Plans; 41 reports on current developments in engineering practice and design; 7 reports on current developments in systems engineering, data processing and the use of computers to solve problems in railway construction, operation and maintenance; 1 report dealing with pollution control; 4 reports dealing with the training and recruiting of employees; 2 economic and analytical studies; 8 reports on relations with public authorities; 2 reports dealing with statistics; and 1 bibliography.

Committee work affecting the AREA Manual included the presentation of 2 tentative specifications as information; the rewriting or revision of 5 specifications; the presentation of 5 recommended practices for adoption and 7 tentative recommended practices as information; the revision or rewriting of 1 recommended practice; and the revision of 1 contract form. Work affecting the Portfolio of Trackwork Plans included the presentation of 5 new plans for adoption.

Discussion Section

During the 1972 Association year, subcommittee reports, papers and addresses published in the technical issues of the Bulletin were again advertised as open for discussion, and a Discussion Section was included in Bulletin 639, September–October 1972.

Personnel of Committees

At the beginning of the 1972 Association year 1153 members were assigned to 1278 places on the Association's 22 technical committees. This compares with 1163 members assigned to 1291 places at the beginning of the previous year. In addition, 9 representatives from 3 standing technical committees were assigned to the Special Committee on Concrete Ties.

AREA committees again were limited to a maximum membership of 70 and to the number from each railroad depending on the total number of AREA members on the railroad.

In the 1972 Handbook of Committee Activity the names of committee chairmen, vice chairmen, secretaries and subcommittee chairmen were again shown in boldface type at the head of each committee roster.

Committee Meetings

To progress work on their assignments the 22 standing AREA technical committees held a total of 56 meetings during the 1972 Association year compared with 55 meetings the previous year. In addition, the Special Committee on Concrete Ties held 3 meetings in 1972. As is usually the case, the majority of these meetings were held in Chicago or at points central to the largest number of committee members. The exceptions were scheduled to permit inspections of facilities, operations or projects which could be seen only by going to those points.

Of the 59 meetings held during the 1972 Association year, 29 were held in Chicago (including the 10 held in March during the 1972 AREA Convention and the 6 held in September during the 1972 Roadmasters' & Bridge & Building Associations Convention); 6 were held in Atlanta, Ga.; 2 each were held in Cincinnati, Ohio, Washington, D. C., and Denver, Colo.; and 18 were held in as many other cities.

The number of meetings held during the year by each committee was dictated by the scope of their work and other considerations. Accordingly, 2 committees each held 4 meetings, 11 committees each held 3 meetings and 9 committees each held 2 meetings. One committee held no meeting during the year.

ASSOCIATION PUBLICATIONS

In 1972 the AREA Bulletin and the AREA News were again published under the schedules put into effect by the Board of Direction in 1970—the Bulletins five times a year and the News on a quarterly basis, Winter, Spring, Summer and Fall. The Bulletins in Proceedings Volume 74 will be Nos. 639, September–October 1972; 640, November–December 1972; 641 January–February 1973; and 643 June–July 1973. Bulletin 642 is the blue-covered April–May Directory Issue, which is not a part of the Annual Proceedings of the Association.

All the Manual recommendations submitted by committees for adoption were again published separate from the committees' informational reports—in Part 1 of Bulletin 640, November–December 1972, and all were approved by the Board of Direction and adopted as recommended practices for inclusion in the AREA Manual for Railway Engineering (Fixed Properties) and the AREA Portfolio of Trackwork Plans.

The 1972 Handbook of Committee Activity was again published in April in the format put into effect in 1970, that is, with two pages of rules of interest to the general committee membership and chief engineering and maintenance officers instead of the 35 pages of detailed rules and style standards intended primarily for the guidance of committee chairmen, vice chairmen, subcommittee chairmen, and secretaries, that had appeared in editions of this publication prior to 1970. These detailed rules and style standards, after complete revision, will be printed in a separate booklet for distribution to committee officers.

The 1972 Supplement to the AREA Manual for Railway Engineering contained 162 pages (81 sheets) and was sold to all interested parties. However, to permit committee members who have purchased separate copies of their committee's Manual Chapter to keep them up to date, copies of the 1972 Supplement Sheets pertaining to their chapters were mailed to committee members without charge, in continuation of a long-established practice.

The 1972 Supplement to the AREA Portfolio of Trackwork Plans included a new title page and Foreword page for the Portfolio, revised contents pages, 11 revised plans for the "Standard Plans" section, and 36 revised plans for the Reference section (that part of the Portfolio following the blue divider sheet). Most of the latter plans were issued to permit removal of the "Errata Section" from Contents page 3, because the corrections to the plans listed in the Errata Section were incorporated in the plans themselves.

In 1972 Bulletin Binders designated as Volume 73, 1972, were sent to all members who had paid for them in advance. This two-part, hard-cover, book-type binder is designed to house all the Bulletins in the publication year, which starts with the September–October issue and ends with the June–July issue, with the exception of the blue-covered April–May Directory issue which is not punched for binding.

The June–July 1972 Bulletin contained all material presented at the March 1972 Convention having technical and historic interest: the president's address, reports of the executive manager and treasurer, special features, panel discussions, and committee reports not previously published in the committee report Bulletins.

LOOKING AHEAD

Here are the presently scheduled dates and locations for future Annual Meetings of the AREA, all at the Palmer House, Chicago:

1974—March 18–20
1975—March 24–26
1976—March 22–24

The next Regional Meeting will be held on October 25, 1973, in the Sheraton Philadelphia, Philadelphia, Pa. Arrangements and planning for the meeting are under the direction of AREA Director B. J. Gordon, chief engineer, maintenance of way, Penn Central Transportation Company.

As reported, our membership level remains high, considering the reduction in the number of engineering employees on the railroads and other factors which prevent participation in Association activities, and our financial situation remains sound—the Association is still going strong. Keeping it strong will require that the Association accomplish its professional responsibilities in behalf of the engineering profession and the railroad industry expeditiously and efficiently, and this it can do with the active support of its officers, directors and members, and all railroad engineering and maintenance officers.

Respectively submitted,

Earl W. Hodgkins,
Executive Manager and Secretary

Deceased Members

T. H. Ary (M '61)
Supervisor Work Equipment, Atchison, Topeka & Santa Fe Railway, San Bernardino, Calif.

W. J. Bennett (M '21, L '47)
Retired Assistant Bridge Engineer, Great Northern Railway, Kirkland, Wash.

R. E. Chambers (M '22, L '56)
Retired District Engineer, Atchison, Topeka & Santa Fe Railway, Laguna Hills, Calif.

M. E. Condon (M '54)*
Assistant Engineer, Erie Lackawanna Railway, Hoboken, N. J.

D. W. Converse (M '26, L '60)
Retired Bridge Engineer, Akron, Canton & Youngstown Railroad, Akron, Ohio

A. A. Cross (A '24, L '64)
Retired Manager, Bird Tie Pads, Inc., West Hartford, Conn.

R. E. Cross (M '44)
Division Engineer, Chessie System, Grand Rapids, Mich.

B. E. Crumpler (M '42, L '71)
Retired Assistant Chief Engineer—Construction, Norfolk & Western Railway, Roanoke, Va.

A. T. Danver (M '28, L '60)
Retired President, Rutland Railway, Rutland, Vt.

O. J. Estep (M '69)
Division Engineer, Chessie System, Saginaw, Mich.

E. D. Feak (M '61)
Retired Assistant Signal and Electrical Engineer, Southern Railway System, Washington, D. C.

J. J. Fiala (M '60)
Partner, Hardesty & Hanover, Consulting Engineers, New York

S. F. Grear (M '20, L '53)
Retired Assistant Engineer of Bridges, Illinois Central Railroad, Anna, Ill.

T. W. Hislop (M '43, L '69)
Retired Supervisor Water Service, New York Central System, Albany, N. Y.

J. T. Hoelzer (M '44, L '70)
Retired Regional Engineer, Baltimore & Ohio, Bradentown, Fla.

A. R. Jones (M '21, L '51)
Retired Division Engineer, New York Central System, Delmar, N. Y.

E. E. King (M '12, L '46)
Retired Professor of Railway Civil Engineering, University of Illinois, Urbana, Ill.

J. S. Knight (M '24, L '57)
Retired Regional Engineer Construction and Maintenance, Baltimore & Ohio Chicago Terminal Railroad, Midlothian, Ill.

A. C. Laessig (A '46, L '71)
Retired President, Unit Rail Anchor Corp., Pittsburgh, Pa.

Thomas Lees (M '19, L '46)
Retired District Engineer, Canadian Pacific Railway, Vancouver, B. C.

C. M. Long (M '31, L '60)
Retired Assistant Engineer, Wabash Railroad, Decatur, Ill.

E. E. Mayo (M '21, L '56)
Retired Vice President, Southern Pacific Pipe Lines, Inc., San Francisco, Calif.

R. L. Mays (M '38, L '69)
Retired Engineer Public Improvements and Contracts, Norfolk & Western Railway, Roanoke, Va.

J. H. McCormick (M '72)
Chief Draftsman, Union Pacific Railroad, Cheyenne, Wyo.

Crosby Miller (M '14, L '46)
Retired Chief Engineer, Chesapeake & Ohio Railway, Irvington, Va.

G. W. Miller (M '39, L '69)
Retired Assistant Chief Engineer, Canadian Pacific Railway, Ottawa, Ont.

B. H. Moore (M '45, L '71)
Retired Assistant to Vice President, Association of American Railroads, Chevy Chase, Md.

Embert Osland (M '47, L '72)
Retired Office Engineer, Atchison, Topeka & Santa Fe Railway, Lombard, Ill.

T. M. Pajari (M '39, L '69)
Retired Division Engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad, Tacoma, Wash.

Henry Petrie (M '48)
Vice President Operations, Tennessee, Alabama & Georgia Railway, Chattanooga, Tenn.

J. S. Parson (M '40, L '69)
Retired Chief Engineer, Erie Lackawanna Railway, Lakewood, Ohio

P. H. Pipkin (M '54)
Assistant Engineer, Southern Pacific Transportation Company, Houston, Tex.

R. W. J. Pryor (M '69)
Soils Engineer, Quebec North Shore & Labrador Railway, Sept Iles, Que.

C. E. Reeves (M '14, L '49)
Retired Consulting Engineer, Buffalo, N. Y.

D. D. Rosen (M '54)
Assistant Engineer, Atchison, Topeka & Santa Fe Railway, Topeka, Kans.

F. A. Russ, Jr. (M '58)
Engineer—Bridges and Buildings, Penn Central Transportation Company, Philadelphia, Pa.

J. W. Smith (M '33, L '68)
Retired Chairman of the Board, Seaboard Coast Line Railroad, Richmond, Va.

C. W. Sooby (A '49)
Retired Manager—Transportation Economics, Signal & Communications Division, WABCO, Pittsburgh, Pa.

F. E. Van Sant (M '67)
Division Engineer, Atchison, Topeka & Santa Fe Railway, Kansas City, Kan.

K. J. Wagoner (M '30, L '59)
Retired Chief Engineer, Baltimore & Ohio Railroad, Baltimore, Md.

E. M. Walters (M '57)
Assistant Engineer Environmental Control, Burlington Northern, Inc., St. Paul, Minn.

L. W. Wells (M '04, L '36)
Retired Consulting Engineer, Dallas, Tex.

S. G. Wintoniak (M '53)
Staff Engineer, Penn Central Transportation Company, Philadelphia, Pa.

REPORT OF TREASURER

Report of the Treasurer

December 31, 1972.

To the Members:

In considering the 1972 budget it was not anticipated that a balanced budget could be achieved; it was estimated that Association disbursements would exceed receipts by $4,010.

A review of the total financial picture of the Association for 1972 shows an excess of receipts over disbursements of $2,673.31. It should be noted that total expenditures, expected to be $125,760, was $125,534.70, very close to the estimate. Receipts, however, estimated at $121,700, actually reached $128,208.01.

Receipts on Membership accounts were up $353 from the 1972 estimate and exceeded 1971 receipts by $2,783.

The invoicing system for notifying members that it was time to pay their annual dues, initiated in 1971, was repeated during the last quarter of 1972. As a result, a large percentage of the membership paid their 1973 dues prior to January 1, 1973, but the Association books, maintained on a calendar year basis, include all payments received for 1973 dues after January 1.

It should be pointed out that revised printing processing and scheduling has eliminated the high periodic cost of printing the Manual and spread a proportional share of that cost into each fiscal year. In other words, the publication cost of the Manual during 1972 is directly related to revenue derived from Manual sales. Portfolio sales and the sale of other publications (Bulletin binders, specifications, etc.) account for the increase in receipts and are a direct result of the sale of the large Portfolio Supplement and two Binders during 1972.

A brief review of the 1972 financial picture shows total receipts much higher than last year. Revenue from membership dues were slightly higher than estimated for 1972 and somewhat higher than 1971, but receipts from the sale of publications were up $10,731.53 over the estimated amount and exceeded 1971 sales by $3,759.68. The balance of the receipts item indicated over/under receipts as follows: Student Affiliate Fees $36.00 under; Advertising $1,763.96 under; Miscellaneous $457.34 over; Interest $375.00 over; Convention $1,670.85 under. The policy to pass the cost of publication shipping on to the purchaser resulted in receipts of $2,704.29 (Publication Shipping).

Manual receipts are continuing on a high level, but somewhat below 1971. Receipts for Trackwork Plans for 1972 are significantly higher than in 1971, increased by receipts from the large Portfolio Supplement issued in 1972.

Due to the efforts of the Special Board Committee on Advertising, including each member of the Board, advertising receipts for 1972 totaled $8,236.04, an increase of $2,793.67, placing revenue from this service at an all time high, with an additional amount of $2,147.50 in outstanding accounts at the end of the year. This has been done in spite of circumstances—reduced advertising budgets of railway supply companies, fewer old-line railway supply companies through mergers and dissolutions, and mergers of old-line companies into conglomerates whose managements have only marginal interest in the railroad industry. These same conditions also confront regular trade publications and are significantly evident in the reduced amount of advertising in that media.

It is hoped that the new Special Board Committee on Advertising will continue the upward trend in advertising and Board members will be further stimulated by this success to bring to the attention of supply company executives who call on them, the advantages of advertising in the AREA Bulletin. Furthermore, the business card directory of consulting engineers is proving to be a popular advertising vehicle for those consulting engineering firms particularly interested in doing work for railroads.

Some Budget items—Social Security, Insurance, Unemployment Tax, Rental, Telephone, Refunds, Miscellaneous and Extraordinary—are comparatively static items and recur with little change in annual expenditure. These should require little explanation.

While many of the Disbursement items are of a recurring nature, Salaries, Special Services and the related items of Social Security and Insurance and Unemployment Tax were under-expended by $4,444.83 due mainly to the fact that the steno–clerk position at headquarters was only filled part time. Traveling expense was over-expended by $771.84.

The total item of Printing was under-expended by $1,385.63.

It should be noted that the volume of publication sales and revenue has more than doubled in the past eight years and continues to increase. To cope with the demands of industry on our mail-order operation has required an increasing amount of correspondence, records and bookkeeping, resulting in a significant increase in the amount of time and materials used, as is reflected in budget items for Miscellaneous Stationery and Printing, Supplies, Miscellaneous and Extraordinary.

In all, we have had another record year for total receipts and have been successful in holding disbursements to the budget level. We will be hard pressed to achieve similar results in 1973. Inflation is increasing virtually all items of AREA expenditures. Thus, to come anywhere near balancing receipts and expenditures in 1973 will require concerted efforts on the part of all officers and members of the Association to increase AREA Membership, and to promote publication sales, and advertising in the Bulletin.

Following is a Comparison of Receipts and Disbursements for the Last 20 Years, the Financial Statement, a Statement of Assets, and a General Balance Sheet.

Respectfully submitted,

A. B. Hillman, Jr.
Treasurer

COMPARISON OF RECEIPTS AND DISBURSEMENTS FOR THE LAST 20 YEARS

	Receipts	*Disbursements*	*Net Gain*
1953	$ 73,033.00	$ 82,067.00	$ 9,034.79*
1954	85,748.99	68,003.03	17,745.96*
1955	80,177.21	73,923.18	6,254.03
1956	79,531.11	70,336.17	9,014.04
1957	85,429.31	89,830.57	4,401.26*
1958	81,454.56	77,348.92	4,105.64
1959	80,407.16	80,297.48	109.68
1960	81,138.79	83,978.29	2,839.50
1961	83,461.73	73,410.20	10,051.53
1962	76,097.28	87,344.12	11,246.84*
1963	73,653.48	66,156.99	7,496.49
1964	74,834.81	78,118.66	3,283.85*
1965	81,336.73	73,895.90	7,440.83
1966	84,590.91	80,454.00	4,136.91
1967	78,724.17	101,087.51	22,363.34*
1968	97,639.94	111,054.20	13,414.26*
1969	109,893.16	112,741.62	2,848.46*
1970	113,245.85	108,305.33	4,940.52
1971	113,756.51	116,003.93	2,247.42*
1972	128,208.01	125,534.70	2,673.31

* Deficit.

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1972

RECEIPTS

Balance on Hand January 1, 1972 (Bonds at Par Value)			$120,666.37
Membership Account			
Entrance Fees	$ 2,640.00		
Dues and Student Affiliate Fees	57,763.00		
		$ 60,403.00	
Sale of Publications			
Proceedings	2,128.50		
Bulletins	3,680.55		
Manuals	17,386.99		
Track Plans	8,756.85		
Specifications	7,074.35		
Publication Shipping	2,704.29		
		$ 41,731.53	
Advertising in Publications	8,236.04		
Annual Meeting Registration Fees	10,829.15		
Interest on Investments	5,875.00		
Interest on Special Savings Account	475.95		
Miscellaneous	657.34		
		$ 26,073.48	
Total		128,208.01	

Disbursements

Salaries and Wages	$32,792.49		
Bulletins and Proceedings	26,390.73		
Stationery and Printing	6,416.01		
Rent	1,140.00		
Shipping Charges	8,133.29		
Supplies	673.31		
Pensions	3,777.12		
Social Security and Insurance, Unemployment Tax	2,572.68		
Manuals	13,899.40		
Refunds	92.95		
Committee and Traveling Expenses	2,171.95		
Newsletter	3,287.77		
Telephone Expense	766.27		
Track Plans	10,836.47		
Professors Expense	5,623.10		
Miscellaneous and Extraordinary	1,272.94		
Annual Meeting	5,688.22		
		$125,534.70	
Excess of Receipts over Disbursements			2,673.31
Balance on Hand December 31, 1972			$123,339.68

STATEMENT OF ASSETS

Balance on Hand January 1, 1972		$120,666.37
Receipts	$128,208.01	
Paid Out on Vouchers	125,534.70	
Excess of Receipts over Disbursements	2,673.31	
Balance on Hand December 31, 1972		$123,339.68
Consisting of:		
Bonds Adjusted to Par Value	$112,000.00	
Cash in Northern Trust Company	498.08	
Savings Account in Northern Trust Company	10,816.60	
Petty Cash	25.00	
Financial Assets with Bonds Adjusted to Par Value ($282.57)		$123,339.68
Balance on Hand December 31, 1972		$123,339.68

GENERAL BALANCE SHEEET—1972

Assets:	
Cash in Northern Trust Company	$ 498.08
Cash in Special Savings Account	10,816.60
Interest on Special Savings Account	122.37
Petty Cash	25.00
Due from Advertising	2,147.50
*Prepaid Postage	1,808.81
Furniture and Fixtures	1,000.00
Inventories:	
Publications on Hand	500.00
Track Plans and Loose Plans	2,829.62
Manuals	1,432.76
Binders	1,648.75
Chapters, Specifications, etc.	3,487.59
Investments	112,000.00
Interest on Investments	952.09
Total Assets	$139,269.17
Liabilities:	
Members Dues Paid in Advance	1,103.25
Surplus	138,165.92
Total	$139,269.17

* Prepaid Postage—Second Class deposit balance:

(1) Madison Post Office	$ 699.10
(2) Chicago Post Office	86.00
—United Parcel Service deposit	100.00
—Balance 12/31/72, Postage Meter	923.71
	$1,808.81

CONSTITUTION

American Railway Engineering Association

CONSTITUTION

Revised to November 14, 1968

Article I

NAME, OBJECT AND LOCATION

1. Name

The name of this Association shall be the AMERICAN RAILWAY ENGINEERING ASSOCIATION.

2. Object

The object of the Association shall be the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways.

3. Means to be Used

The means to be used for this purpose shall be:

(a) The investigation of matters pertaining to the object of the Association through Study and Research Committees.

(b) Meeting for the presentation and discussion of papers, and for action on the recommendations of committees.

(c) The publication of papers, reports and discussions.

4. Conclusions

The conclusions adopted by the Association shall be recommendatory.

5. Location

The office of the Association shall be located in Chicago, Ill.

Article II

MEMBERSHIP

1. Classes

The membership of this Association shall be divided into five classes: Members, Life Members, Honorary Members, Associates and Junior Members.

2. Qualifications

A. GENERAL

(a) An applicant to be eligible for membership in any class other than that of Junior Member shall be not less than 25 years of age.

(b) To be eligible for membership in any class, or for retention of membership as a Member, an Associate or a Junior Member, a person shall not be engaged directly or primarily in the sale to the railways of appliances, supplies, patents or patented services.

(c) The right to membership shall not be terminated by retirement from active service.

(d) In determining the eligibility for membership in any class, graduation in engineering from a school of recognized standing shall be considered as equivalent to three years of active practice, and satisfactory completion of each year of work in such school, without graduation, shall be considered as equivalent to one-half year of active practice.

(e) In determining the eligibility for Member under Section B (a) of this Article, each year of practical experience in engineering, or in science related thereof, prior to employment on a railway, if such experience were of the same specialized character as the current work of the applicant, shall be considered as equivalent to one year of railway service.

B. Member

A Member shall be:

(a) A railway engineer or officer who has had not less than five years' experience in the location, construction, operation or maintenance of railways and who is employed by a common-carrier railway corporation, by an approved association of railroads or railway engineers or officers, or by a non-common-carrier railway if his primary duties consist entirely or primarily of the location, construction, operation or maintenance of a railway plant and facilities.

(b) A dean, professor, assistant professor, or equivalent in engineering in a university or college of recognized standing, or an instructor or equivalent in such university or college, who, with an engineering degree, has had at least two years' experience in teaching engineering.

(c) An engineer or member of a public board, commission or other official agency who, in the discharge of his regular duties, deals with railway problems.

(d) An editor of a trade or technical magazine who, in the discharge of his regular duties, deals with railway problems, and who has had the equivalent of five years' engineering or railway experience.

(e) A consulting engineer or contractor, or an engineer in their employ, engaged in the engineering, construction and maintenance of railroad-related facilities or an engineer employed by a technical service or research and development organization who has had the equivalent of five years' engineering experience.

(f) An officer or engineer of an engineering or scientific society or association whose aims and objectives are compatible with the aims and objectives of this association.

C. Life Member

A Life Member shall be a Past President of the Association who has been retired under a recognized retirement plan, or a Member or an Associate who has paid dues for 35 years or who has been retired under a recognized retirement plan and has paid dues for not less than 25 years.

D. Honorary Member

(a) An Honorary Member shall be a person of acknowledged eminence in railways engineering or management.

(b) The number of Honorary Members shall be limited to ten.

E. Associate

An Associate shall be:

(a) A member of a railway supply company or association who meets the qualifications of Section 2, Paragraph A (a) and (b).

(b) A person qualified by training and experience to cooperate with Members in the object of this Association, but who is not qualified to become a Member.

F. Junior Member

(a) A Junior Member shall be not less than 21 years of age, shall have had not less than three years' experience in the location, construction, operation or maintenance of railways, and shall be an employee of a railway corporation, or one of the organizations or institutions listed under Section B of this Article, or a railway supply company if he qualifies under Section 2, Paragraph A (b) of this Article.

(b) His membership in this classification in the Association shall terminate at the end of the calendar year in which he becomes 30 years of age.

(c) He may make application for membership other than as a Junior Member at any time when he becomes eligible to do so.

3. Transfers

The Board of Direction shall transfer from one class of membership to another, or may remove from membership, any person whose qualifications so change as to warrant such action.

4. Rights

(a) Members, and Life Members who were formerly Members, shall have all the rights and privileges of the Association. Life Members who were formerly Associates shall continue to have all the rights and privileges of Associates.

(b) Honorary Members shall have all the rights and privileges of the Association except those of holding elective office, provided, however, that Members or Life Members who are elected Honorary Members shall retain all the rights and privileges of the Association.

(c) Associates and Junior Members shall have all the rights and privileges of the Association except those of voting and holding elective office.

Article III

Admission, Resignation, Expulsion and Reinstatement

1. Charter Membership

The Charter Membership of this Association consists of all persons elected to membership before March 15, 1900.

2. Application for Membership

(a) A person desirous of membership in this Association shall make application upon the form provided by the Board of Direction. In the event that Junior Membership is desired, the applicant shall so state.

(b) The applicant shall give the names of at least three Members of this Association to whom personally known. Each of these Members shall be requested by the Executive Manager of the Association to certify to a personal knowledge of the applicant with an opinion of the applicant's qualifications for membership.

(c) If an applicant is not personally known to as many as three Members of this Association, the names of well-known persons engaged in railway or allied professional work to whom he is personally known shall be substituted, as necessary, to provide a total of at least three references. Each of these persons shall be requested by the Executive Manager of the Association to certify to a personal knowledge of the applicant, with an opinion of the applicant's qualifications for membership.

(d) No further action shall be taken upon the application until replies have been received from at least three of the persons named by the applicant as references.

3. Election to Membership

(a) Upon completion of the application in accordance with Section 2 of this Article the Board of Direction through its Membership Committee shall consider the application and make such investigation as it may consider desirable or necessary.

(b) Upon completion of such consideration and investigation, each member of the Board of Direction shall be supplied with the required information, together with the recommendation of the Membership Committee as to the class of membership, if any, to which the applicant is eligible, and the admission of the applicant shall be canvassed by ballot among the members of the Board of Direction.

(c) In the event that an application has been made under the provisions of Section 2, Paragraphs (a) and (b) of this Article, a two-thirds affirmative vote of the entire Board of Direction shall be required for election.

(d) In the event that an application has been made under the provision of Section 2, Paragraphs (a) and (c) of the Article, a unanimous affirmative vote of the entire Board of Direction shall be required for election.

4. Subscription to the Constitution

An applicant for any class of membership in this Association shall declare his willingness to abide by the Constitution of the Association in his application for membership.

5. Honorary Member

A proposal for Honorary Membership shall be endorsed by ten or more Members of the Association and a copy furnished each member of the Board of Direction. The nominee shall be declared an Honorary Member upon receiving a unanimous vote of the entire Board of Direction.

6. Resignation

The Board of Direction shall accept the resignation, tendered in writing, of any person holding membership in the Association whose obligations to the Association have been fulfilled.

7. Expulsion

Charges of misconduct on the part of anyone holding membership in this Association, if in writing and signed by ten or more Members, may be submitted to the Board of Direction for examination and action. If, in the opinion of the Board action is warranted, the person complained of shall be served with a copy of such charges and shall be given an opportunity to answer them to the Board of Direction. After such opportunity has been given, the Board of Direction shall take final action. A two-thirds affirmative vote of the entire Board of Direction shall be required for expulsion.

8. Reinstatement

(a) A person having been a Member, an Associate or a Junior Member of this Association and having resigned such membership while in good standing may be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

(b) A person having been a Member, an Associate or a Junior Member of this Association and having forfeited membership under the provisions of Article IV, Section 3, may, upon such conditions as may be fixed by the Board, be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

Article IV

Dues

1. Entrance Fee

(a) An entrance fee of $10 shall be payable to the Association with each application for membership other than Junior Membership. This sum shall be returned to an applicant not elected.

(b) An entrance fee of $5 shall be payable to the Association with each application for Junior Member, which sum shall be returned to an applicant not elected. When a Junior Member transfers to the Member or Associate Member class the previously paid $5 entrance fee shall be credited towards the entrance fee for the class to which transferring. However, the Junior Member entrance fee shall not be returnable should the individual resign from the Association or allow his membership to lapse. Neither shall it be applicable to the dues for any year.

2. Annual Dues

(a) The annual dues for each Member and each Associate shall be $20.

(b) The annual dues for each Junior Member shall be $7.50.

(c) Life Members and Honorary Members shall be exempt from the payment of dues. Life Members desiring to continue to receive the Bulletins and Proceedings of the Association may do so by paying a subscription fee prescribed by the Board of Direction

3. Arrears

A person whose dues are not paid before April 1 of the current year shall be notified by the Executive Manager. If the dues are still unpaid on July 1, further notice shall be given, informing the person that he is not in good standing in the Association. If the dues remain unpaid by October 1, the person shall be notified that he will no longer receive the publications of the Association. If the dues are not paid by December 31, the person shall forfeit membership without further action or notice, except as provided for in Section 4 of this Article.

4. Remission of Dues

The Board of Direction may extend the time of payment of dues, and may remit the dues of any Member, Associate or Junior Member who, for good reason, is unable to pay them.

Article V

Officers

1. Officers

(a) The officers of the Association shall be a President, two Vice Presidents, twelve Directors, an Executive Manager and a Treasurer.

(b) The President, the Vice Presidents, the Directors and the two Past Presidents on the Board of Direction shall be Members and shall act as the trustees and have the custody of all property belonging to the Association.

(c) The Executive Manager and the Treasurer shall be appointed by the Board of Direction.

2. Term of Office

The term of office of the President shall be one year, of the Vice Presidents two years and of the Directors three years. The term of each shall begin at the close of the annual convention at which elected and continue until a successor is qualified. All other officers and employees shall hold office or position at the pleasure of the Board of Direction.

3. Officers Elected Annually

(a) There shall be elected at each annual convention a President, one Vice President and four Directors.

(b) The candidates for President and for Vice President shall be selected from the members or past members of the Board of Direction.

4. Conditions of Re-election of Officers

A President shall be ineligible for re-election, except as provided for in Section 5 (e) of this Article. Vice Presidents and Directors shall be ineligible for re-election to the same office, except as provided for in Section 5 (e) of this Article, until, at least one full term has elapsed after the end of their respective terms.

5. Vacancies in Offices

(a) If a vacancy should occur in the office of President, as set forth in Section 6 of this Article, the senior Vice President shall immediately and automatically become President for the unexpired term.

(b) If a vacancy should occur in the office of the senior Vice President, due to advancement under Section 5 (a) of this Article, or for reasons set forth in Section 6 of this Article, the junior Vice President shall automatically become senior Vice President for the unexpired term.

(c) If a vacancy should occur in the office of the junior Vice President, due to advancement under Section 5 (b) of this Article, or for reasons set forth in Section 6 of this Article, the Board of Direction shall by the affirmative vote of two-thirds of its entire membership, select a junior Vice President from the members or past members of the Board of Direction.

(d) A vacancy in the office of Director, due to advancement of a Director to junior Vice President under Section 5 (c) of this Article, or for reasons set forth in Section 6 of this Article, shall be filled by the Board of Direction by the affirmative vote of two-thirds of its entire membership.

(e) An incumbent in any office for an unexpired term shall be eligible for re-election to the office held; provided, however, that anyone selected to fill a vacancy as Director shall be eligible for election to that office, excepting that such appointee filling out an unexpired term of two years or more shall be considered as coming within the provisions of Section 4 of this Article.

6. Vacation of Office

(a) In the event of the death of an elected officer, or his resignation from office, or if he should cease to be a Member of the Association as provided in Section 2 (B), Article II; Section 6 or 7, Article III; or Section 3, Article IV, the office shall be considered as vacated.

(b) In the event of the disability of an officer or neglect in the performance of duty by an officer, the Board of Direction, by the affirmative vote of two-thirds of its entire membership shall have the power to declare the office vacant.

Article VI

Nomination and Election of Officers

1. Nominating Committee

(a) There shall be a Nominating Committee composed of the five latest living Past Presidents of the Association, who are Members, and five Members who are not officers.

(b) The five Members who are not Past Presidents shall be elected annually for a term of one year, when the officers of the Association are elected.

(c) The senior Past President who is a member of the committee shall be the chairman of the committee. In the absence of the senior Past President from a meeting of the committee the Past President next in seniority present shall act as chairman.

(d) If one or more Past Presidents are unable to act as members of the committee through disability, the President shall have the authority to appoint an equivalent number of eligible next senior Past Presidents to the committee as ordinary members.

(e) If one or more elected members of the committee are unable to act, through death or disability, the President shall have the authority to appoint as replacements an equivalent number of the senior unsuccessful candidates for election to the committee.

2. Method of Nominating

(a) At least three months prior to the annual convention, the Chairman shall call a meeting of the committee at a convenient place, at which nominees for the several elective offices shall be selected as follows:

Office to be Filled	*Number of Candidates to be named by the Nominating Committee*	*Number of Candidates to be elected at the Annual Election of Officers*
President	1	1
Vice President	1	1
Directors	8	4
Nominating Committee	10	5

(b) The nominations for Director shall maintain the territorial balance prescribed in Article VII, Section 1, Paragraph (b), to the maximum extent practicable. In this connection, the nominations for Director shall be predicated, insofar as practicable, on the following three-year repeating pattern of Director positions to ensure adequate territorial distribution:

First Year	Second Year	Third Year
East—2	East—1	East—1
South—1	West—2	South—1
West—1	Canada—1	West—2

Nominations in any one year shall be double the number of positions available for each district that year, with the nominations listed separately by districts.

(c) The elected members of the Nominating Committee each year shall include one from each district represented on the Board of Direction and one at-large member. Nominations in any year shall be double the number of positions available for each district, with the nominations listed separately by districts.

(d) The Chairman of the Nominating Committee shall send the names of the nominees to the President and Executive Manager within 15 days after the meeting of the Nominating Committee, and the Executive Manager shall report the names of these nominees to the members of the Association not less than 60 days prior to the annual convention.

(e) At any time prior to 30 days before the annual convention, any ten or more Members may send to the Executive Manager additional nominations for any elective office for the ensuing year, signed by such Members.

(f) If any person nominated shall be found by the Board of Direction to be ineligible for the office for which nominated, or should a nominee decline such nomination, his name shall be withdrawn. The Board of Direction may fill any vacancies that may occur in the list of nominees up to the time the ballots are sent out.

3. Ballots Issued

Not less than thirty days prior to each annual convention, the Executive Manager shall issue a ballot to each voting Member of record who has paid his dues to or beyond December 31 of the previous year, listing by districts the several candidates to be voted upon. When there is more than one candidate for any office, the names shall be arranged on the ballot in the order within each district that shall be determined by lot by the Nominating Committee. The ballot shall be accompanied by a statement giving for each candidate his record of membership and activities in the Association.

4. Substitution of Names

Members may remove names from the printed ballot list and may substitute the name or names of any other person or persons eligible for any office, but the number of names voted for each office on the ballot must not exceed the number to be elected at that time to such office.

5. Ballots

(a) Ballots shall be placed in an envelope, sealed and endorsed with the name of the voter, and mailed to or deposited with the Executive Manager at any time previous to the closure of the polls.

(b) A voter may have the privilege of withdrawing his ballot, for the purposes of casting another, or otherwise, at any time up to ten working days prior to the closure of the polls. After that date, no ballot shall be subject to withdrawal or revision.

(c) Ballots received in unendorsed envelopes, or from persons not qualified to vote, shall not be counted.

(d) The ballots and envelopes shall be preserved for not less than ten days after the vote is canvassed.

6. Closure of Polls

The polls shall be closed at 12 o'clock noon on the first day of normal 2½-day annual conventions, and at 4 pm on the day prior to the first day of annual conventions which are less than 2½ days in length. In both instances, the ballots shall be counted by tellers appointed by the presiding officer.

7. Election

(a) The persons who shall receive the highest number of votes for the offices for which they are candidates shall be declared elected.

(b) In case of a tie between two or more candidates for the same office, the Members present at the annual convention shall elect the officer by ballot from the candidates so tied.

(c) The presiding officer shall announce at the convention the names of the officers elected in accordance with this Article.

Article VII

Management

1. Board of Direction

(a) The Board of Direction shall be the governing body of the Association and shall manage the affairs of the Association in accordance with the Constitution of the Association, and shall have full power to control and regulate all matters not otherwise provided for in the Constitution. It shall be composed of seventeen Members of the Association, and shall include the President and two Vice Presidents of the Association, the two living junior Past Presidents, and twelve elected Directors. The nomination and election of the Officers and Directors shall be in accordance with the procedures set forth in Article VI herein.

(b) Furthermore, the membership shall, insofar as possible, include proportional representation from the territorial divisions contained in the "List of Principal Railroads Showing Allocation to Geographical Groups" (published in the current issue of The Official Railway Equipment Register).

Accordingly, the twelve Directors shall be elected in accordance with Article VI, Section 2, to fit, insofar as possible, the following general plan for territorial representation:

Four from the Eastern District, including the Allegheny and Pocahontas Districts; two from the Southern District; five from the Western District, including the Northwestern, Central Western and Southwestern Districts; and one from Canada.

(c) The President and two Vice Presidents of the Association and the two Past Presidents on the Board of Direction shall be at-large members of the Board.

(d) Vacancies occurring in Director positions prior to normal expiration of term of office shall be filled by the Board, insofar as possible, from the district represented by the previous incumbent.

(e) The Board of Direction shall meet within thirty days after each annual convention, and at such other times as the President may direct. Special meetings shall be called on request, in writing, of five members of the Board of Direction.

(f) Seven members of the Board of Direction shall constitute a quorum.

2. Executive Committee

(a) An Executive Committee of the Board of Direction shall be constituted annually and shall consist of the President and two Vice Presidents of the Association and the two Past Presidents on the Board of Direction. The Executive Committee shall be subject to confirmation of the Board of Direction each year at the first meeting of the Board following the Convention. The President of the Association shall be the chairman of the Executive Committee.

(b) The Executive Committee shall possess and may exercise during intervals between meetings of the Board, all of the powers of the Board on matters which in the judgment of a majority of the Executive Committee cannot properly be delayed until the next meeting of the Board. Actions of the Executive Committee shall be authorized by a concurring majority of its full membership and shall be reported to the Board of Direction at its next meeting.

(c) The Executive Committee may be dissolved at any time by action of a majority of the full membership of the Board of Direction. Following such dissolution, the Executive Committee may be re-created with personnel different than prescribed in Paragraph (a) herein at any time prior to the Annual Convention by action of a majority of the full membership of the Board. However, if the Executive Committee is not re-created prior to the next Annual Convention it automatically shall come under the provision of Paragraph (a) herein unless the Board of Direction decrees otherwise.

3. President

The President shall have general supervision of the affairs of the Association, shall preside at meetings of the Association, the Board of Direction and the Executive Committee of the Board of Direction, and, by virtue of his office, shall be a member of all committees, except the Nominating Committee.

4. Vice Presidents

The Vice Presidents, in order of seniority, shall preside at meetings in the absence of the President.

5. Treasurer

The Treasurer shall pay all bills of the Association when properly certified by the Executive Manager and approved by the Finance Committee. He shall make an annual report as to the financial condition of the Association and such other reports as may be called for by the Board of Direction.

6. Executive Manager

The Executive Manager shall be appointed by the Board of Direction to manage the affairs of the Association under the direction of the President and the Board of Direction. He shall be the Executive Officer and the Secretary of the Association, and shall serve as secretary of the Board of Direction and of the Executive Committee of the Board of Direction.

The Executive Manager shall attend the meetings of the Association and of the Board of Direction and the Executive Committee of the Board of Direction, prepare the business therefor, and record the proceedings thereof. Furthermore, he shall see that all money due the Association is collected, is credited to the proper accounts, and is deposited in the designated depository of the Association, with receipt to the Treasurer therefor. He shall personally certify to the accuracy of all bills and vouchers on which money is to be paid. In addition, he shall invest all funds of the Association not needed for current disbursements, as shall be recommended by the Finance Committee of the

Board of Direction and approved by the Board of Direction, with notification to the Treasurer of such investments.

The Executive Manager shall be responsible for the handling of the correspondence of the Association, shall make an annual report to the Association, shall have direct charge of the property and quarters of the Association, shall direct the work of the secretaries, assistant secretaries and other employees of the Association, and shall perform such other duties as the Board of Direction may prescribe.

7. Auditing of Accounts

The financial accounts of the Association shall be audited annually by an accountant or accountants approved by and under the direction of the Finance Committee.

8. Administrative Committees

At the first meeting of the Board of Direction after the annual convention, the following Administrative Committees, each consisting of not less than three members, shall be appointed by the President. The personnel of these committees shall be subject to approval by the Board of Direction.

Assignments
Finance
Manual
Membership
Personnel
Publications
Research

Other special Administrative Committees may be appointed by the President at any time, and reappointed annually, if necessary, their personnel being subject to approval by the Board of Direction.

Membership on Administrative Committees shall be restricted to members of the Board of Direction, except that one or two members of the Administrative Committee on Research may be past members of the Board of Direction.

9. Study and Research Committees

The Board of Direction may establish continuing or special Study and Research Committees to investigate, consider, and report upon subjects appropriate to the object of the Association, as set forth in Art. I.

10. Duties of Administrative Committees

(a) Assignments

The Assignments Committee shall review and pass upon the recommendations of Association Study and Research Committees for subjects to be investigated, considered and reported on by these committees during the ensuing Association year, and shall report thereon to the Board of Direction for its approval. The Assignments Committee shall have authority to assign additional subjects or change the scope of any existing subjects at any time during the year, reporting its action thereon to the Board at its next regular meeting.

(b) Finance

The Finance Committee shall have immediate supervision of the accounts and financial affairs of the Association; shall approve all bills before payment, and shall make recommendations to the Board of Direction as to the investment of funds and other financial matters. The Finance Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money other than the amounts necessary to meet ordinary current expenses of the Association, except by authority of the Board of Direction.

(c) Manual

The Manual Committee, with the assistance of the Publications Committee, shall have general supervision over the Manual.

(d) Membership

The Membership Committee shall investigate applicants for membership and shall make recommendations to the Board of Direction with reference thereto.

(e) Personnel

The Personnel Committee shall review and pass upon applications of members for appointment to Study and Research Committees, and shall also appoint the chairman and vice chairman of such committees and make a report thereon to the Board of Direction for its approval. Should an unexpected vacancy in chairmanship or vice chairmanship of any such committee occur, the Personnel Committee shall have authority to fill such vacancy immediately, reporting its action thereon to the Board at its next regular meeting.

(f) Publications

The Publications Committee shall have general supervision over the publications of the Association. The Publications Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money except by authority of the Board of Direction.

(g) Research

The Research Committee shall encourage and coordinate the research activities of the Association, in the course of accomplishment of which it shall review and pass upon the recommendations of Study and Research Committees for research projects and shall report thereon to the Board of Direction, recommending for approval specific projects initiated by these committees or by the Research Committee and recommending allotments of funds for these projects in the research budget of the Association of American Railroads or from other sources compatible therewith; shall collaborate closely with the research staff of the Association of American Railroads; and when called upon by the Vice President—Research or the Vice President—Operations and Maintenance of that association, members of the Research Committee shall engage in the activities of advisory committees or groups of that organization and shall report from time to time to the Board of Direction on those activities.

11. Special Committees

The Board of Direction may appoint special committees to examine into and report upon any subject connected with the objects of this Association.

12. Discussion by Non-Members

The Board of Direction may invite discussions of reports from persons not members of the Association.

13. Sanction of Act of Board of Direction

An act of the Board of Direction which shall have received the expressed or implied sanction of the membership at the next annual convention of the Association shall be deemed to be the act of the Association.

Article VIII

Meetings

1. Annual Convention

(a) The Annual Convention of the Association shall be held in the City of Chicago, Ill., or in such other city as may be determined by the affirmative vote of two-thirds of the entire membership of the Board of Direction. The convention in any year shall be held on dates determined by the affirmative vote of two-thirds of the entire membership of the Board of Direction.

(b) The Executive Manager shall notify all members of the Association of the time and place of the annual convention at least 30 days in advance thereof.

(c) The order of business at the annual convention of the Association shall be:

Address of the President
Reports of the Executive Manager and the Treasurer
Reports of committees
Unfinished business
New business
Installation of officers
Adjournment

(d) This order of business may be changed by a majority vote of Members present.

(e) The proceedings shall be governed by "Robert's Rules of Order" except as otherwise herein provided.

(f) Discussions shall be limited to Members and to those others invited by the presiding officer to speak.

2. Special Meetings

Special meetings of the Associations may be called by the Board of Directions on its own initiative, and may be so called by the Board of Direction upon written request of 100 Members. The request shall state the purpose of such meeting.

The call for such special meeting shall be issued not less than ten days in advance of the proposed date of such meeting and shall state the purpose and place of the meeting. No other business shall be taken up at such meeting.

3. Quorum

Twenty-five Members shall constitute a quorum at all meetings of the Association.

Article IX

Amendment

1. Amendment

Amendment of this Constitution may be proposed by written petition signed by not less than ten Members of the Association, and shall be acted upon in the following manner:

The proposed amendment shall be presented to the Executive Manager who shall send a copy to each member of the Board of Direction as soon as received. If a majority of the entire Board of Direction so votes, the matter shall be submitted to the voting members of the Association by letter ballot.

Amendment to the Constitution also may be proposed by majority affirmative vote of the entire Board of Direction, and the proposed amendment then submitted to the voting members of the Association by letter ballot.

Sixty days after the date of issue of the letter ballot, the Board of Direction shall canvass the ballots which have been received, and if two-thirds of such ballots are in the affirmative the amendment shall be declared adopted and shall become effective immediately. The result of the letter ballot shall be announced to members of the Association.

Note on Annual Tie Statistics

The statistics providing information on cross tie renewals and average tie costs for the year 1972, as compiled by the Economics and Finance Department, Association of American Railroads, will be published in Bulletin 644, September–October 1973, Proceedings Volume 75, instead of in this issue of the Bulletin because some of the statistical data was not available at the time of going to press.

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