The Engineer in Field and Office

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New Ideas for Securing Uncommonly Quick, Accurate and Economical Results. Reprinted from the Engineering News-Record.

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PREFACE

Civil Engineering is an art of which it can never be said that it "stands still." It keeps pace with human needs—and human necessities are ever expanding.

Every year—every month—almost every week—witnesses fresh demands for more conveniences, quicker transportation, more effective safeguards for public health and comfort.

In meeting these demands, civil engineers are, happily, most efficient. The profession is continually making new discoveries—putting forth new inventions—suggesting new applications of former theories—devising more effective designs—improving upon the old methods.

Recognizing its obligations to the field it serves, the *Enginering News-Record* not only opens its columns freely to the authors and originators of these new ideas so that their experiences may be passed along for the benefit of others, but is continually seeking out the new and helpful.

These advances thus become incorporated into the common practice long before they get into the books or become part of the teachings of the schools.

The best of the new ideas which have recently appeared in the *News-Record* have been collected for this volume.

The editors feel that many of them are too valuable to remain hidden in the files of a periodical, even of a journal whose back numbers are so frequently consulted as are those of the *Engineering News-Record.*

They are confident that in this accessible and permanent form this new material will be helpful to every engineer who wishes his work to be abreast of the times. *It is Civil Engineering brought up to date.*

For the most part, in the case of the contributed articles we have let the engineers tell their own story. But little editorial responsibility has been assumed, beyond the elimination of occasional personal and local references in the articles as they originally appeared in the columns of the *Engineering News-Record.* The mere fact that they were admitted to these columns is sufficient guarantee of their good faith and of the editors' judgment of their worth as contributions to current practice.

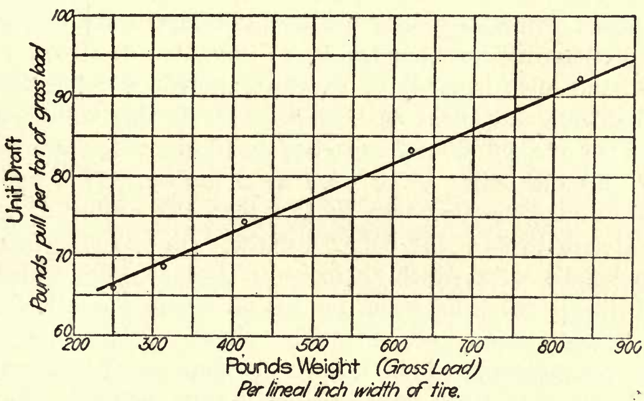
CONTENTS

The Engineer in Field and Office

Of Value to the Highway Engineer

Traction Is a Straight-Line Function of Tire Width

It has been recognized for many years that the narrow steel tire is enormously destructive to earth and gravel roads. The formation of a rut begins practically with the passage of the first vehicle improperly equipped. The U. S. Department of Agriculture has shown that the effort necessary to draw a certain load is an inverse



Graph Shows Uniformity of Test Conditions

function of the tire width, and in this manner forwards another argument against excessive load concentrations on the road surface.

The accompanying curve is plotted from data obtained under similar conditions of moisture and atmosphere. The earth road was plowed, graded and rolled between each series of tests, and its condition throughout the investigation was probably as uniform as the nature of the test warranted. A gross wagon load of 5000 lb. was maintained, the tire width being varied from 1½ in. to 6 in.

The unit draft decreases directly as the weight per inch width of tire decreases, until a weight of 250 lb. per inch of tire is reached, as is indicated by the curve. The draft for a 6-in. tire is larger than that for a 5-in. tire. This was uniformly true, and indicates that there is not only nothing gained by increasing the width beyond a certain point, but there may be a positive disadvantage in so doing.

Handling Hot Oil on Maintenance

By H. M. Lukens

The Los Angeles County Highway Department has a unique system of heating and distributing oil in the maintenance of its paved ways. The oil is too cold for use when it reaches the job in trucks from the main depot. It is poured into buckets that have previously been arranged in two rows with another row on top. A portable distillate and water burner has proved very efficient. As many as 80 buckets of oil can be heated to 500° F. in about 15 min. About 15 or 20 gal. of oil at this temperature is placed in the hand oiler for direct application to the patch or street.

The hand oiler is made of sheet iron, with a boiler about 2½ ft. in diameter and about 3½ ft. high. Inside this boiler hangs a cast-iron pot of about 20 gal. capacity, the intervening space between the pot and the boiler being used as a firebox. This apparatus is so suspended on two iron wheels that the center of gravity is low enough to keep the boiler upright. On one side is riveted an iron handle with which to move it, and opposite and on top of the boiler is the hand crank for the oil pump, which is fastened to the bottom of the oil pot. The pump, of the rotary type, is driven by sprocket and chain from the hand crank and is capable of developing 6 to 10 lb. pressure per square inch. To the pump is attached 20 ft. of ¾-in. metallic hose with a piece of ¾-in. pipe 3½ ft. long at the discharge end. This end is plugged so that under pressure a spray is formed which may be regulated by a throttle. The maximum capacity of the machine is about 125 gal. per hour.

It has been found from experience that best results are had from heating the oil to the desired temperature in the buckets and using it in the hand oiler without any additional fire in the firebox. Fire in the oiler causes the bottom of the oil pot to cake up, which in time breaks loose and clogs the pump.

Concealed Wood Strips for Transverse Joints

Many of the troubles attending the use of transverse joints in concrete pavements can be avoided by installing at the bottom of the slab a $\frac{3}{8}$-in. wooden strip of about half the depth of the concrete. In this manner planes of weakness where transverse cracking may concentrate, are definitely located.

Four joints of this type were installed in 1915, and withstood the following winter without cracking, although fine hair cracks appeared in June, 1916. These cracks were very narrow and followed a zigzag line around the individual stones of the concrete directly over the wooden strip. The zigzag cracks nowhere departed more than 2 in. from a straight line. These cracks were exposed to traffic all summer, and no spalling of any kind has been noticed.

The result was so satisfactory that in 1916 10 consecutive joints of the same type were installed on each of two roads. These have gone through one winter and are now in excellent shape. Fine hair cracks have appeared over most of the joints, but the fact that the pavement has not yet cracked over a few indicates that the slabs might have been made somewhat longer than 30 ft. in this particular locality. In no case has the pavement cracked, except over the wooden strips.

The advantages obtained by this method over other types of joints are: (1) No spalling along the joints; (2) no interference with screeding or floating, and a much smoother pavement; (3) the joints are cheaper and easier to install, the wood may be of cheap material and need not be creosoted; (4) better appearance of the road.

The advantages of this method over no joints at all are that by choosing the proper length of slab to correspond to the width of pavement and to climatic conditions the cracks will be minimized and will run square across the pavement at regular intervals instead of occurring haphazard and running in every direction.

It is absolutely necessary that the top of the joint be kept below the surface of the slab a sufficient distance to give body enough to the concrete over it to prevent spalling. This minimum depth has not yet been definitely determined, but from observations already made, a distance of $2\frac{1}{2}$ in. near the edges and $3\frac{1}{2}$ in. near the center of the pavement seems to work out very well. Should this distance be much greater, it probably would necessitate decreasing the length of the slab in order to insure the cracking at the joints only.

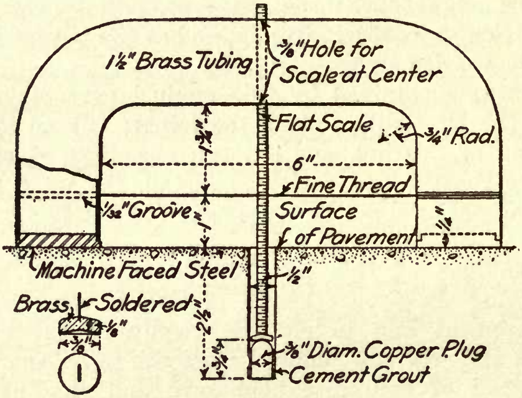
A simple way to prevent the wooden joints floating up through the concrete is to drive short pegs at intervals of about 7 ft. across the road and nail through the strip into the pegs. Bent wires hooked over the joint would answer the same purpose. The strips should be installed by means of a taper installing board in the usual manner.

Exact Wear of Concrete Pavements Measured

By A. N. Johnson

Consulting Highway Engineer, Portland Cement Association, Chicago

The usual methods that have been devised for measuring the wear of macadam roads are open to considerable error, aside from usually being rather clumsy, but the method here proposed overcomes many difficulties and is also extremely simple and convenient. A drill hole ½ in. in diameter is made in the pavement. In the case of a concrete pavement it may be 2 or 2½ in. in depth. In the



With This Device Wear of Concrete Can Be Easily and Accurately Measured

bottom of the drill hole is set a copper plug about ¾ in. long, with its top made semi-spherical. The plug is embedded in the hole with cement paste. A short steel scale divided into inches and hundreds, small enough to be placed in the drill hole, is provided. At its end is a small button with conical undersurface, which is to rest on the spherical end of the copper plug. The hole is filled with a wood plug, left flush with the surface, which is to be removed when readings are to be made.

A convenient method of measuring is to have a U-shaped handle, which will span about 6 in., having flat ends on the legs. Drawn between the supports is a tightly stretched thin thread or wire 1 in. from the surface of the pavement. This is to be held so that the thread will be over the center of the drill hole. The flat ends of the legs rest on the pavement surface and the measurements are made to the thread. The thread may first be placed longitudinally with respect to the pavement, then transversely, and in as many other positions as desired.

Grasses To Protect Road Embankments

By W. C. Buetow

Division Engineer, Wisconsin Highway Commission, La Force, Wis.

Much damage to embankments and slopes that cannot be prevented even by the provision of proper drainage and keeping cattle from trampling the slopes can be taken care of by the planting of well-chosen grass, which should be properly cared for until a mat or blanket has formed.

Grasses do not form a mat or blanket very quickly, due to the variance of the climatic conditions. The action of frost is the most disturbing factor, and on account of the depth of its penetration the upper stratum of the bank is kept in a loosened state that is very susceptible to the spring rains.

When selecting grasses to be planted on the slopes, it should be kept in mind, therefore, that a grass with a good system of roots is to be used, as well as one able to withstand the hot rays of the sun. Grasses that will grow on a sunny bank probably will not take root and form a mat on the shaded slopes, in which case a different kind of grass is necessary.

The protection to the bank lies almost wholly in the ability of the roots to interweave so minutely as to form a system to reinforce the surface stratum. Hungarian brome grass, Canadian blue grass, fescue grasses and Western wheat grass are good to plant. In many cases sod is handy to get and, when properly cut and placed, offers very good protection. The sods must be held in place by wooden pegs until the grass has taken root.

Seeding and planting are equally successful when conducted properly. The surface in each case must be prepared in order to make it at all conducive to a good growth. The seed cannot be merely distributed on the slope and left with the hope that it will catch. If necessary, the ground should be manured before any seeding is done and if a sandy slope is treated, the surface must be protected from the wind with straw or brush until the grasses are able to withstand the elements.

Different kinds of soil require a certain kind of grass or a combination of several kinds. For shaded places a combination of Kentucky blue grass, wood meadow grass, crested dog's tail and various leaved fescues are well adapted.

Clay soils can be treated with a mixture of Kentucky blue grass, English rye and fancy red top. The rye grass gives an early quick result, the red top makes a bottom grass, and the blue grass is the permanent feature.

Sandy soils require a quickly growing binding grass that will withstand the drought. Creeping bent, Rhode Island bent and fine-leaved fescue are grasses that answer this purpose. Western wheat grass has unusual ability to grow on the sunny side of an embankment. Creeping bent, Canada and Kentucky blue grass and crested dog's tail are quick growing, deep-rooting grasses that will bind the soil until such time as the more permanent grasses are in possession. Sweet clover and creeping honeysuckle are recommended for planting in cuts.

Dump Road Drags Before Pulling Across Railroad Crossings

Men operating road drags should dump their drags or unhook one end of the drag chain and pull the drag endwise whenever a railroad crossing must be crossed, according to the "Bulletin" of the Iowa State Highway Commission. Railroad men are complaining that this precaution is not being taken. They have appealed to the commission to do all in its power to get dragmen to watch this point. Pulling the drag across the tracks in the usual manner leaves the space between the rails and the planking on each side filled with dirt and small stones. Each passing train packs this material down, and the next dragging fills the space again. This continues with every dragging; and if a good-sized hard hand-stone becomes packed in this space, there is the best possible situation developed for a derailment. Derailments of hand cars and motor cars are of almost daily occurrence because they are not heavy enough to crush the dirt and stone sufficiently to allow the wheels to retain a safe hold on the rails. There have been many derailments of trains traceable to this cause, but so far, no serious wrecks.

A New Subgrader Design

Instead of the usual scraper blade at right angles to the center line of the road, a new subgrader used in California has four pairs of plow-shaped blades arranged to balance the thrust. These are set at an angle with the center line, and as a result the tendency to pile up earth ahead of the grader is avoided. This feature makes possible more work of a satisfactory character with fewer laborers than is obtainable from the ordinary type of subgrader.

A feature of the new device is the quadrant and lever regulation of the blade, whereby the height of the blade can be adjusted without the use of special tools. This arrangement also permits raising the blades until the scraper rests on a central circular plate, or turntable, in which position it can be easily swung parallel to the center line of the road to allow space for passing vehicles, or so that it may be trundled off the graded roadbed. Angle irons are provided as guides to keep the wheels on the header.

Since the blades shear through the material rather than pile it up ahead, depressions in the subgrade are avoided to a great extent. The grade may be controlled to a nicety on account of the clean action of the plow blade, and thus a considerable saving in concrete is effected. It is notable that the setting of the blade at acute angles has reduced the tractive effort below that required by the ordinary grader. The most effective work has been done when the grader is hauled by cables running from its extreme ends to the tractor, which is kept about 30 ft. in advance.

Earth-Road Maintenance by Contract

By C. S. Bennett

State Engineer and Inspector, Greenup, Ky.

After considering various methods of maintenance for the new roads of Greenup County, Ky., it was decided to adopt the contract method. The specifications as finally drawn up embody provisions for dragging, cleaning ditches and culverts, cutting weeds on the county's right-of-way, maintaining a crown, etc. Bids were then asked for and work on each section was let to the lowest responsible bidder. Mileage was considered the basis for payment, while slides and washouts were paid for by the cubic yard. The work was usually let in five-mile sections.

A road drag, two drag scrapers, one wheel scraper, shovels, and mattocks, were furnished to each contractor, being charged against him with the provision that at the expiration of his contract he account for all tools supplied to him. In addition, two large blade road graders were purchased by the county, being lent to the various contractors as they were needed in shaping up the roads in the spring season. A contractor was required to own at least one team.

The work was under the supervision of the county road engineer, who notified the contractors when they were to drag the roads and when to cut the weeds on the county's right-of-way. He also issued to them instructions as to other details of the work.

Payments were made quarterly, the payments being so distributed as to make a maximum payment fall at a time when the greatest amount of maintenance was necessary. Thus, for instance, a contract dated Jan. 1, 1916, stated that payments would be made to the contractors as follows: 20% Apr. 1; 40% July 1; 15% Sept. 1 and 25% Dec. 31. The maximum payment, 40%, was made at the end of the spring season, during which time the greatest amount of work is necessary to keep the roads in condition. In addition, each contractor was required to give bond for the faithful performance of the work called for in his contract. Strict adherence to the terms of the contract, especially in regard to dragging the roads, was insisted upon.

The cost of maintenance on seven sections of road for the year 1916 is as follows:

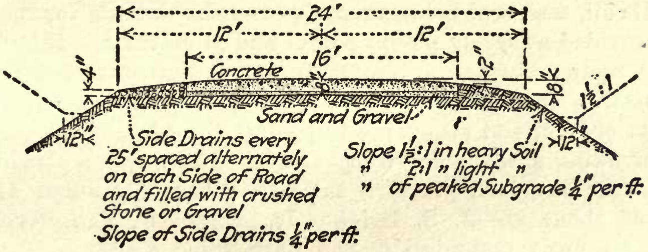
Contract No.	Length, Miles	Bid per Milerper Maintenance	Bid per Cubic Yard for Earth	Bid per Cubic Yard for Rock	Total Cost per Mile
45 D 1	4	$45.00	0.35	0.40	$48.50
45 C 1	5	56.00	0.37	0.37	61.05
45 G 1	5	40.00	0.24	0.35	40.35
45 G 2	5	60.00	0.30	0.30	76.22
45 E 1	3	53.00	0.35	0.40	53.00
45 A 1	5	100.00	0.20	0.50	138.00
45 G 3	3	75.00	0.35	0.60	75.00

From a comparison made with similar work done in other counties under various other methods, the writer is led to believe that the contract method, properly looked after, is the cheapest method of continuous maintenance for earth roads.

Peaked Subgrade Provides Better Underdrainage

A concrete or brick slab laid with a flat bottom upon a flat subgrade affords no possibility for underdrainage. As a result, seepage through the pavement at various points—such as expansion joints, along car rails, and through semiporous spots—keeps the subgrade moist and affords a good chance for frost upheavals with the resultant cracking of the rigid surface. While there is but slight importance attached to such seepage if the construction is on a sandy or porous soil, a clay or heavy soil brings about conditions which cannot be disregarded.

The ordinary precaution of laying a slab with a crowned bottom upon a crowned subgrade does not entirely alleviate these conditions, as the slab is laid directly upon the heavy soil, filling every crevice and blocking a free movement of the water from under the crust.



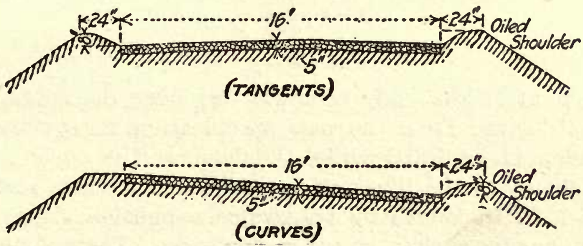
Peaked Subgrade Brought Level with Sand or Gravel Affords Best Possible Drainage

The newer specifications, which require 2 or 3 in. of sand to be laid upon the flat subgrade, and upon this sand bed to lay a flat-bottomed slab, are undoubtedly an improvement, but it is questionable whether this method will prove to be entirely sufficient.

The subgrade should not be crowned, but peaked, as indicated in the illustration. On this a sand covering about 2 or 3 in. in thickness at the center can be well rolled to a flat surface. This will allow a free movement of the water between the bottom of the slab and the top of the impervious subgrade and should afford adequate protection against the troubles outlined in the foregoing.

Oiled Shoulders Resist Erosion

A mountain road in San Bernardino County, Calif., with a maximum grade of 5% presented a serious problem in the protection



Oiled Road Shoulders, San Bernardino County, California

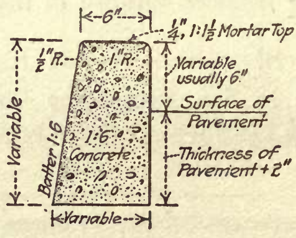
of high embankments from the wash of storm water running off the paved surface. The problem would have been simple if funds had been available for concrete curbs and gutters. Instead, the following plan, illustrated in the accompanying cross-sections, was adopted: The shoulders for 2 ft. in width were raised from 6 to 8 in. by filling with the adjacent gravelly soil, and were rounded off to easy curves. The shoulders were then given two coats of 75% asphaltic oil, each coat being properly sanded. Cutouts for the water were provided at safely placed points and at culverts. This method of construction formed an earth curb, and the pavement acted as the gutter. The oiled shoulders have a sufficiently hard surface to resist erosion and also serve to protect the edge of the macadam from breaking down under wheel traffic. There was a considerable saving over standard practice, the cost being only about 2½c. per lin.ft. of shoulder.—J. S. Bright, Jr., Engineer, San Bernardino County Highway Commission, San Bernardino, Calif.

Curb with Integral Expansion Joints

By E. E. Kirkpatrick

City Engineer, Bartlesville, Okla.

Better quality of work, better and more positive expansion joints, less risk in construction, better protection against drying, elimination of the danger of mortar scaling, elimination of the damage caused by removing templets and forms while the work is green, and a better top facing owing to the fact that it is placed

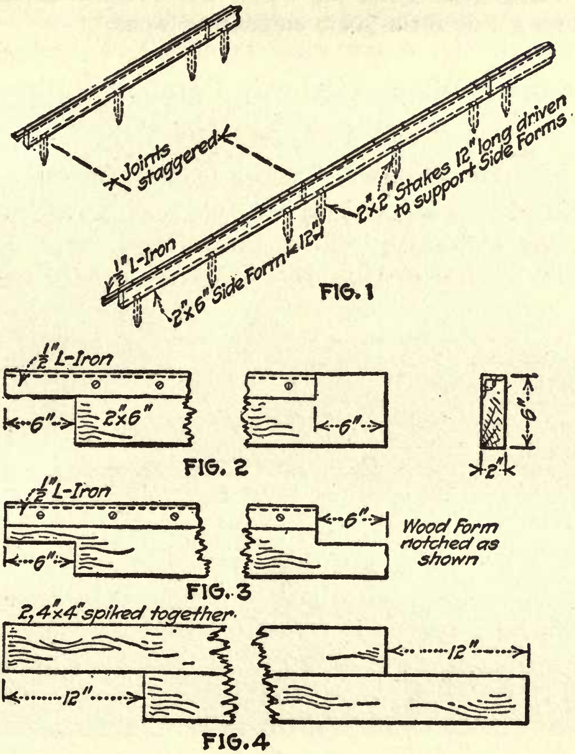


immediately after the body concrete has been deposited, are the advantages derived from the new specification for concrete curbs recently adopted by Bartlesville, Oklahoma. The curb, of the dimensions shown in the illustration, is blocked off into sections not exceeding 7 ft. in length by transverse expansion strips not less than $\frac{3}{32}$ in. nor more than $\frac{3}{16}$ in. in thickness. These strips, placed before the concrete is deposited, are composed of asphalt-roofing sheets, asphaltic felt or other elastic asphaltic material cut to the form of the cross section of the curb.

The concrete is spaded thoroughly, the expansion strips being held in place by thin boards or metal strips that are raised as the concreting progresses. The mortar top dressing is placed as soon as the form is filled. Dressed lumber is used for forms, and the concrete is mixed to such consistency that with proper spading a perfect face is obtained.

Save Trouble by Using Well-Built Forms

As the engineer watches the ordinary contractor set his side forms for concrete roadwork, he easily realizes that not enough consideration is given to their construction and grade layout—facts



Stands Much Rough Handling

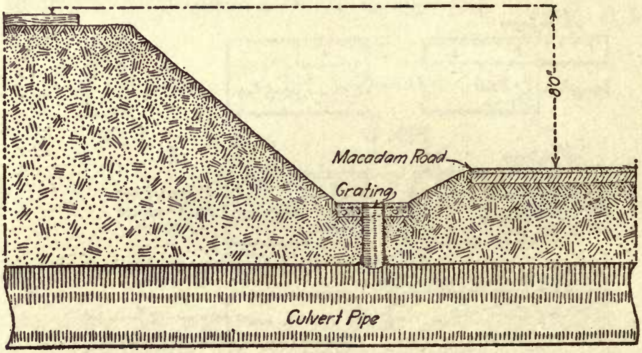
which later on are sure to cause much extra trouble and loss of time. The forms should not of course be built to a degree of over-nicety, but should be so constructed as to prevent their becoming easily bent, warped or worn out of shape. Another feature oftentimes overlooked is the desirability of staggering the joints, thus preventing an undulation forming across the road in case the joints are out of grade. To obtain a method of easily supporting side forms for grade, 2 x 2-in. wooden stakes are driven to the proper elevation of the bottom of the form; and they, in conjunction with alignment stakes which are not shown, and together with the method of staggering the joints, make a satisfactory arrangement. Figs. 2 and 3 show details of wooden side-form construction, Fig. 2 showing the angle iron extending 6 in. beyond the end to insure that adjacent forms will be maintained at the same elevation. Fig. 3 shows a modified design that prevents the angle iron from becoming easily bent when the forms are roughly handled, while Fig. 4 shows a side form made entirely of wood.

Drainage Where Highway Parallels Railroad

By C. S. Bennett

Highway Engineer, Greenup County, Kentucky

In constructing a section of a state-aid road in Greenup County, Kentucky, the highway paralleled the railroad for a distance of one-half mile. The railroad fill is 8 ft. higher than the road surface

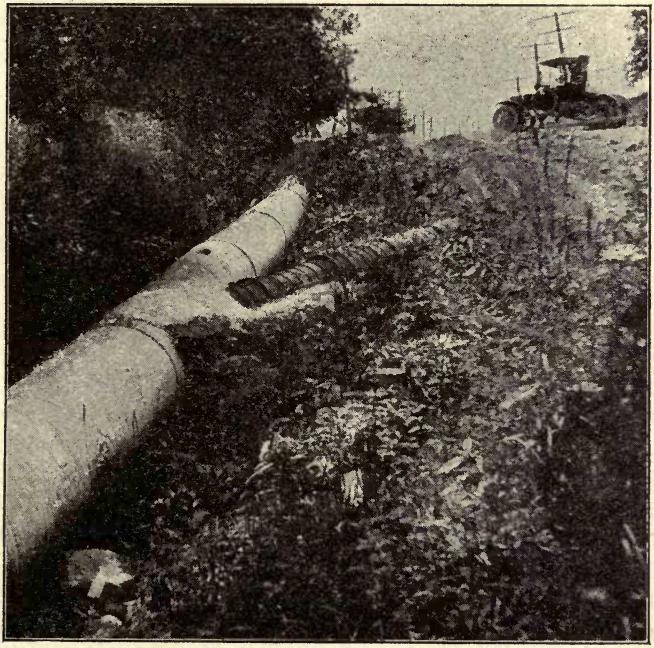


Drop Inlet Takes Care of Drainage Where Railroad Parallels Highway

for about half of this distance. As all culverts extended through both fills, it was decided to adopt the inlet method used on paved roads and streets. Excavations were made in the ditch line over the existing pipe culverts, all of which were 48 in. in diameter and of corrugated iron, and a section was sawed out of the top of the pipe. Short sections of 12-in. corrugated culvert pipe were then placed on end, and fastened to the large pipe by means of an easily made metal collar through which several bolts were run. The top of the riser pipe was provided with a concrete apron 6 in. thick, the width of the bottom of the ditch, and extending about 3 ft. along the ditch. A few small reinforcing bars were inserted in the green concrete, and formed an effective grating which excluded foreign materials.

Unusual Road Drainage

Lincoln Highway, east from Wooster, Ohio, at this point dips from a comparatively level stretch to a grade of some 6 to 8%. Across the ridge where the road begins to dip is an intersecting road at right angles. At this point there was a culvert pipe on both



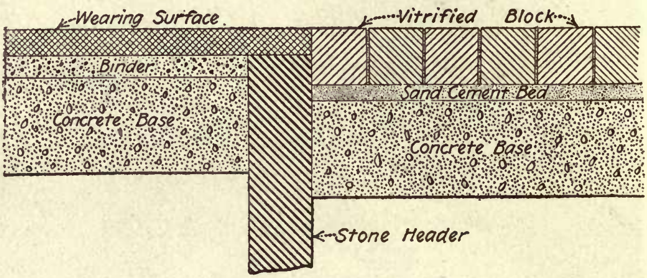
Unusual Drainage, Lincoln Highway, Ohio

sides, while open ditches were provided for drainage of the side hill and to carry considerable accumulated water from the more level place above.

To avoid scouring on the deep side ditches on the improved road, about 300 ft. of 30-in. corrugated-iron culvert pipe extending from the crest of the hill to a creek at the foot of the hill has been installed. Apparently it is not intended to be covered. Drainage water from the level stretch on the opposite side of the road passes through a culvert pipe at the crest and then is conducted diagonally across the roadbed into the large culvert pipe by a segmental cast-iron culvert pipe.

Stone Header Prevents Failures in Paving

Baltimore, Md., has adopted a detail of pavement construction to prevent failures at such points where a hard paving material like granite block, brick or wood block adjoins a softer material like asphalt. This detail is as follows: A well-jointed stone header, 12 in. or more in depth and 4 or 5 in. in width, is constructed across

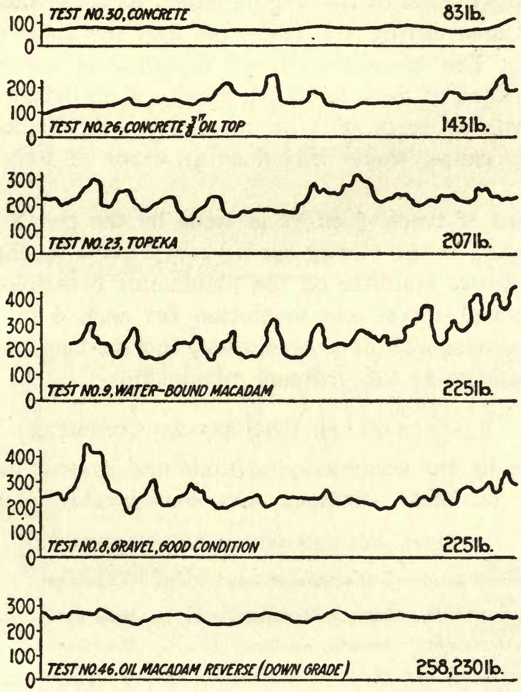


Sunken Stone Header Prevents Failures in Paving

the street parallel to and 1½ in. below the finished surface. The concrete base is placed on one side of the header for the block pavement, and on the other side for the asphalt pavement. The blocks are laid tight against the header, which in case of a 3½-in. vitrified block gives a 2-in. bearing. When the asphalt is laid, the binder course is brought flush with the header; and the topping or wearing surface is laid over the header to the finished contour of the street, thus leaving the header 1½ in. below and entirely hidden from view.

Road Surface Affects Tractive Effort

A series of tests has just been completed in California which was planned to determine the tractive effort required to move vehicles over various types of roads. Tests of a similar character which were previously made, notably by the U. S. Office of Public Roads and Rural Engineering, afforded no data suited to California conditions or which could be used as the starting point for the further series of tests in tire wear and gasoline consumption which is contemplated.



Dynamometer Curves Vary Much

In planning the tests, it was decided to concentrate effort on securing constant conditions for a short length of time during which measurements could be made, rather than to make long runs and average the results. This policy was considered the best where experiments were to be made on the open highways and on several types of roads. One vehicle was therefore equipped and moved at the same speed over the various road surfaces to be compared. For this service a standard farm wagon was selected, equipped with steel axles of equal length and 38- and 46-in. wheels in front and rear, respectively, all wheels having 4-in. tires. The gross load was 3 tons, consisting of rice in sacks. The speed was kept very close to 2.4 miles per hour, and tests were run on level grades or, where slight grades were unavoidable, test runs were made in both directions and results averaged. At the time of the tests the usual sunny summer weather obtained, with maximum temperature of 105°.

The tractive effort was measured by a small dynamometer attached to the tongue of the wagon, which recorded the momentary pull at all times during the test runs and the total pull for the test period. The measurement of distance is accomplished by unwinding a cord of definite length from a drum within the device. In a 50-ft. run an error of 6 in. in cord length, due to stretching or any other cause, would introduce an error of only 1% in the result.

The record of tractive effort is made by the pencil actuated by a lever attached to the strong spring compressed by the pull. The integrating device operates on the planimeter principle, but as the measuring wheel makes one revolution for each 4 in. and can be read to one-thousandth of a revolution, the instrument is 10 to 20 times as sensitive as the ordinary planimeter.

Results Favor Unsurfaced Concrete

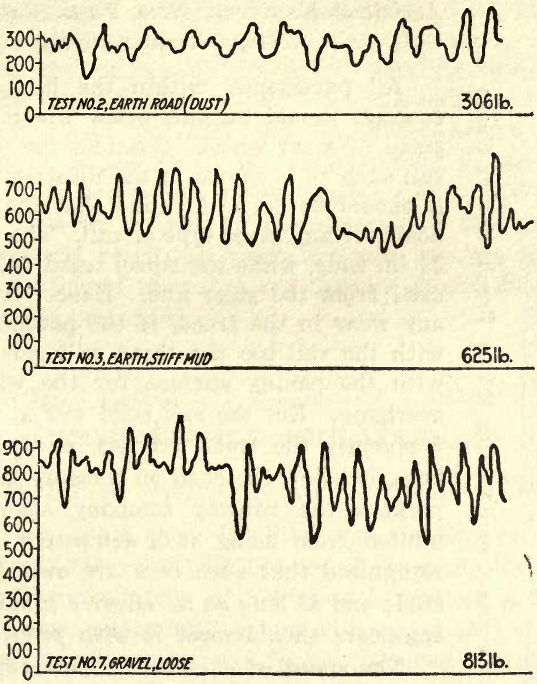
As shown by the accompanying table and curves, the resistance encountered on oiled surfaces was considerably more than on

TYPICAL RESULTS FOR VARIOUS SURFACES

Test No.	Kind of Road	Condition of Road	Location	Tract. Resist. Total	Tract. Resist. Per Ton
29–30–31	Concrete (unsurfaced)	Smooth, excellent	Near Davis	83.0	27.6
*11–12	Concrete (unsurfaced)	Smooth, excellent	Near Davis	90.0	30.0
26–27–28	Concrete (⅝-in. surface asphaltic oil and screenings)	Smooth, excellent	Near Davis	147.6	49.2
13–14	Concrete (⅝-in. surface asphaltic oil and screenings)	Smooth, excellent	Near Davis	155.0	51.6
9–10	Macadam (water-bound)	Smooth, excellent	Near Davis	193.0	64.3
22–23	Topeka on concrete)	Smooth, excellent	Near Davis	205.5	68.5
8	Gravel	Compact, good condition	Near Davis	225.0	75.0
†45–48	Oil macadam	Good, new	Near Sacramento	234.5	78.2
‡46–47	Oil macadam	Good, new	Near Sacramento	244.0	81.3
33	Gravel	Packed, in good condition	Near Davis	247.0	82.3
18–19–20	Topeka on plank	Good condition, soft, wagon left marks	On Causeway near Davis	265.0	88.3
34	Earth road	Firm, 1½-in. fine loose dust	Near Davis	276.0	92.0
24–25	Topeka on plank	Good condition, but soft	Near Davis	278.0	92.6
1–2–5	Earth road	Dust ¾ to 2 in.	Near Davis	298.0	99.3
3–4	Earth	Mud, stiff, firm underneath	Near Davis	654.0	218.0
6–7	Gravel	Loose, not packed	Near Davis	789.0	263.0

*Graphic record indicates that the load was being accelerated when test was started. †Drawn with motor truck at 2½ miles per hour. ‡Drawn with motor truck at 5 miles per hour.

concrete. It was pointed out that this difference would be less at lower temperature, but the tests were made under normal conditions in the central California valleys.

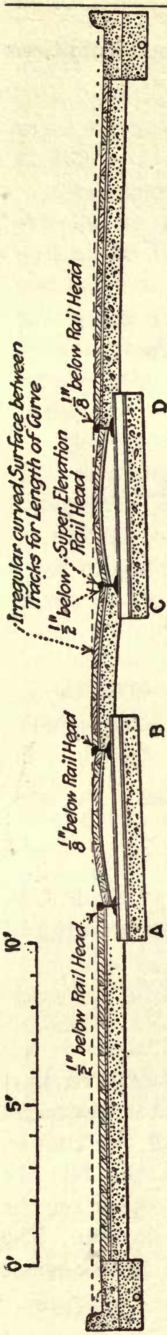


Curves for Tests Nos. 2, 3 and 7

The supervision of the tests has been in the hands of Prof. J. B. Davidson, of the University of California, who is the inventor of the dynamometer.

Side-Hill Fill Held by Trees

In the construction of one of the roads in the northern part of New York State the side-hill fill has to be made over a wooded area. The usual procedure in such cases is to cut off the timber, leaving the ground clear before beginning to make the fill. In this case it has been decided to leave the trees standing on the supposition that by so doing the fill will be less apt to slip. The only clearing of trees which will be allowed will be in the space included between shoulder lines.



Suggested Relation of Rails, Pavement and Gutters Where Tracks Are on Curve

Pavement Along Rails Should Be Lowered

By E. W. Wendell

Assistant Engineer, New York State Highway Department, Albany

All pavements, within the line of possible contact, should be laid below the plane of the tread of a car wheel. Consider the case of a T-rail such as is shown in the illustration—though it should be borne in mind that the above rule holds for any other type of rail. The rail head is 2½ in. wide, while the wheel tread is 3 in., measured from the gage line. Hence, even without any wear in the tread, if the pavement is flush with the rail top the tread will ride in contact with the paving surface for the width of the overhang. But the rail head wears, and not infrequently the tread grooves, so that the overhang is below the head on tangent track. While perhaps the railway company should be prohibited from using such equipment, it must be recognized that such cars are owned and operated; and as long as an adverse condition exists, engineers should meet it with proper design.

The speed of cars being generally regulated by law to a certain safe maximum, there is no necessity for elevating the outer rail on curves to an amount that will distort the cross-section of the street and spoil the section. The illustration shows a 2-in. elevation, but this is more than will be found in practice except in very unusual cases. This section shows clearly the details and dimensions used to overcome the destructive effect of the overhanging tread, but even on tangents at least a ⅛-in. difference in grade should be maintained between the rail head and the pavement surface directly adjacent to it. On curves the amount of superelevation must first be decided upon, as from this is determined the difference in elevation between the rail head and the pavement surface on the inside of the curve.

The following are good rules to follow in determining these points: (1) Place the outside rail (*D* in the section) at the elevation it would have were the track on a tangent; (2) in the case of double tracks, give *B* the same elevation as *D*, if there is not much longitudinal grade at the curve. This plan leaves the half of the street on the outside of the curve with its normal crown, and gives the other half a proper slope toward the gutter. If there is much grade, an inlet may be located before the curve is reached, to catch the gutter drainage, so that *D* can be placed even with, if not below, the gutter grade; and *B* will be at the elevation of *C*, with *A* below *B* the amount of the outer elevation. This method results in track drainage for the side of the street at the outside of the curve and thereby eliminates the gutter as a factor in the drainage.

Interesting Lights on Building Construction-Theory, Design and Methods

A Standard Notation for Beam Flexure

The engineer should be as familiar with the application of the formula for beam flexure as with the use of the multiplication table. Because this formula is one of the most important in the whole subject of stresses, a standard system of notation is desirable.

Sixty years ago Rankine gave in his "Applied Mechanics" the fundamental equation, $M = pI/y$. Later writers have departed from the notation of Rankine. A few present-day notations will be quoted.

TEXTBOOKS

Church	$M = \frac{pI}{e}$
Heller	$M = \frac{sI}{v}$
Kent	$M = \frac{SI}{c}$
Ketchum	$M = \frac{fI}{c}$
Lanza	$M = \frac{pI}{y}$
Merriman	$M = \frac{SI}{c}$
Trautwine	$M = \frac{SI}{T}$

STEEL-MILL HANDBOOKS

Bethlehem	$m = \frac{fI}{n} = fS$
Cambria	$M = \frac{pI}{X_1} = pS$
Carnegie	$M = \frac{fI}{n} = fS$
Jones & Laughlin	$Mr = \frac{fI}{n} = fS$
Lackawanna	$M = \frac{PI}{C_1} = PS$

It is true that variance in notation causes little trouble to engineers making constant use of the equations, but to those who use them only occasionally it is a cause of annoyance. The writer suggests the following as a standard notation:

A STANDARD NOTATION FOR BEAM FLEXURE

b	= Width of beam, in inches
d	= Depth of beam, in inches
Section	= Section cut by plane perpendicular to longitudinal axis of beam
A	= Area of section, in square inches
c	= Distance from the neutral axis to the extreme fiber of section, in inches
I	= Moment of inertia of section about neutral axis, in inches to the fourth power
Iv	= Moment of inertia of section about axis parallel to neutral axis, in inches to the fourth power
v	= Distance between these axes, in inches
r	= Radius of gyration about neutral axis, in inches
L	= Length of span, in feet
l	= Length of span, in inches
W	= Total load uniformly distributed, in pounds
w	= Uniform load per foot of length, in pounds
P	= Load concentrated at any point, in pounds
M	= Total bending moment at any section, in inch-pounds
f	= Stress, in extreme fiber of section in pounds per square inch
S	= Section modulus, in inches to the third power
E	= Modulus of elasticity, in pounds per square inch (steel = 29,000,000)
D	= Maximum deflection, in inches
X-X, Y-Y	= Axes of coördinates
x, y	= Distances of any point from axes of coördinates, in inches

General formulas: $Iv = I + Av^2$; $I = Ar^2$; $S = \frac{I}{c}$; $M = fS = \frac{fI}{c}$

The letter *n* is universally used for the elasticity ratio between steel and concrete, or $E_s \div E_c$. For this reason the letter *c* is used in the above notation for the distance from the neutral axis to the extreme fiber of section.

Stitch-Riveting of Struts

In a built-up member, fastenings between the parts are required only at points at which these parts tend to move relatively to each other. The usual practice in designing compression members, however, is to fasten the elements together in such manner as to guard against any increase in the slenderness ratio in any element of the column. Is this safe enough?

Suppose we have a strut made of two 6 x 3½ x ½-in. angles spaced ½ in. apart, of length 96 in. Assuming the two angles to act together, $r = 1.45$ in., and $l/r = 66.2$. The minimum r for this angle (Fig. 1) is 0.67 in.; hence, if we put the pin rivets at the center of length, we have a slenderness ratio of $48 \div 0.76$, or 63.1, which is slightly less than that of the main column.

In Fig. 2 is given an elevation of the column looking at the face of the outstanding legs. Here is shown by means of dotted lines the deflection that the column would probably take if given a load aproaching its maximum capacity. There would be no tendency at the middle section for one angle to move axially relatively to the other. The column would act, as far as the deflection illustrated in Fig. 2 is concerned, as a column of length equal to *twice* the distance between pin rivets. In this case $r = 0.97$ (see Fig. 1). Multiplying 0.97 by 66.2, we have 64.2 as twice the allowable spacing of pin rivets. This calls for connections at each third-point of the length.

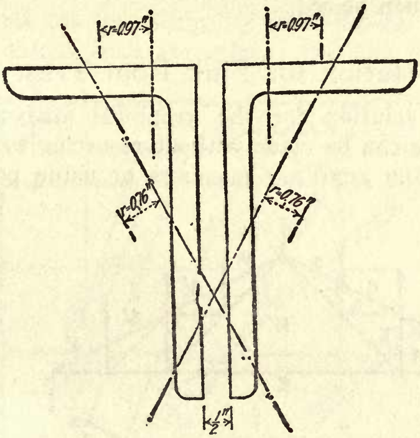


FIG. 1

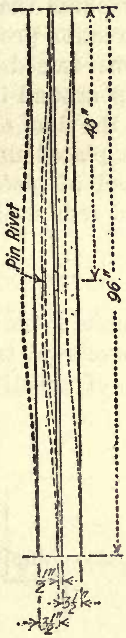


FIG. 2

With a middle rivet only, the slenderness ratio for parallel axes is 96 ÷ 0.97, or 99. By the A.R.E.A. formula the allowable stress for this ratio is 9070 lb. per sq.in., while the allowable stress for the entire column section, slenderness ratio 66.2, is 11,370 lb. per sq.in. Under the latter load the angles considered as independent elements would be loaded 25.3% over their allowable stress.

Method of Erecting a Large Steel Dome

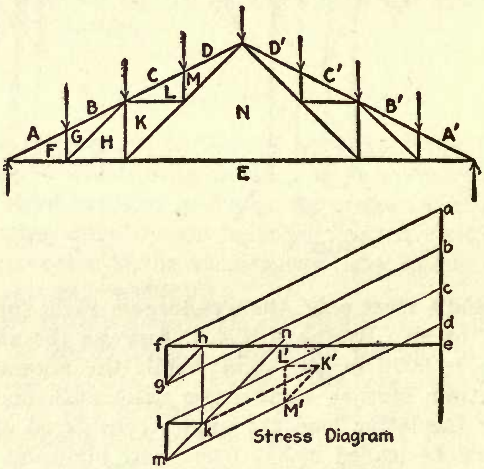
The 92-ft. dome of the Wealthy St. Baptist Church, Grand Rapids, Mich., has a steel frame formed by eight main arch members 35 ft. in span, with 19-ft. rise, framing into an octagonal crown diaphragm, 22 ft. wide across the points. The arches are tied together at the heel by four trusses and four sets of angle ties.

The arches are 2 ft. deep at the top and 5 ft. at the outer extremity. Three lines of beams parallel to the base ties carry the wooden ceiling and roof joists. The lateral bracing consists of a system of rods together with a line of struts in the center of each bay at right angles to the roof beams. A steel monitor frame 8 ft. high surmounts the structure.

The erection procedure was as follows: A derrick of the required height was raised, and the eight sides of the diaphragm were riveted up around its base. With two sets of blocks, the ring was raised to the final elevation, 45 ft. above the floor, and light timber falsework placed underneath. The arches were raised with a gin pole, bolted in place, and the base ties erected. The roof beams, struts and rods were then placed.

Graphic Solution for Fink Roof Truss

A simple general solution for the graphical analysis of the Fink type of roof truss can be made without resorting to the usual expedient of substituting auxiliary members or using partly ana-



Modified Fink Truss Analyzed Graphically

lytical methods. For example, consider the modified Fink truss shown in the diagram. The only load affecting the truss members *LM* and *LK* is *CD*, and hence these stresses can be readily found graphically.

Select any convenient point M' on the line drawn through d in the force diagram parallel to the rafter of the truss. Draw $M'L'$ parallel to ML, giving L' on the line through c. Draw $L'K'$ parallel to LK, and $M'K'$ parallel to MN, as shown. The triangle $L'M'K'$ thus formed gives the true stresses in ML and LK, and also the true relative position of the point K' with respect to the parallel lines through c and d.

The true position of K', however, must be on a line through h parallel to HK, and therefore lies at k in the stress diagram found by $K'k$ drawn parallel to the rafter. With k located, the remaining stresses are found as usual. The method can be applied to any loading and to unsymmetrical Fink trusses.

Design of Concrete Retaining Walls

Diagrams for the designing of retaining walls are simpler and more convenient than formulas. For the purpose of illustration

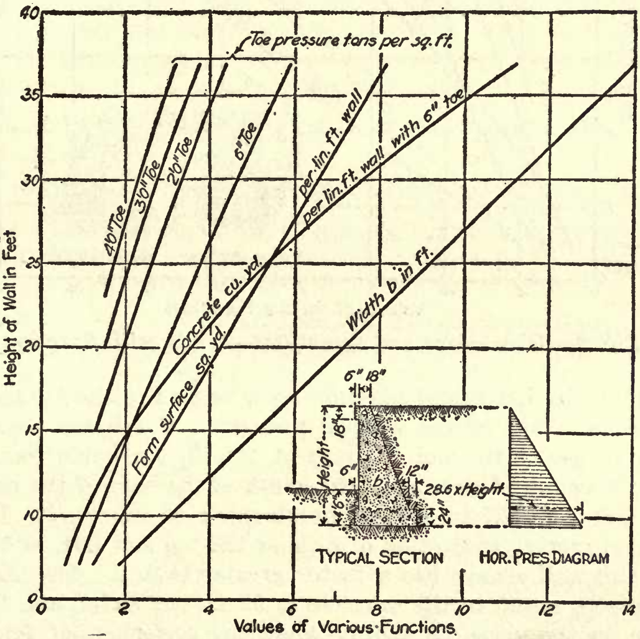


Fig. 1. Dimensions and Quantities—Walls Without Surcharge

two cases will be considered—(1) that of a gravity wall without surcharge, and (2) that of a gravity wall with railroad surcharge of Cooper's E-55 loading, with center line of track 8 ft. 6 in. from the face of the coping.

A gravity retaining wall of the type shown in Fig. 1, which is safe against overturning, will also be safe against sliding and crushing the masonry, and with a suitable toe may be built upon any ordinary foundation. We may then assume a minimum factor of safety against overturning and find the widths of the base for various heights. Assuming that the slope of repose of the filling

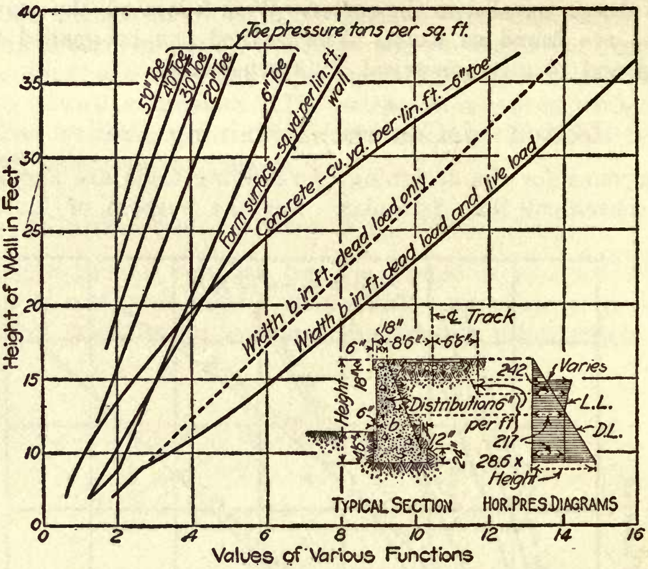


Fig. 2. Dimensions and Quantities—Walls with Surcharge

is 1½ to 1, the horizontal pressure on a vertical plane is, according to Rankine, 0.286 of the vertical pressure. Earth has been taken at 100 lb. per cu.ft., and concrete at 150 lb. per cubic foot.

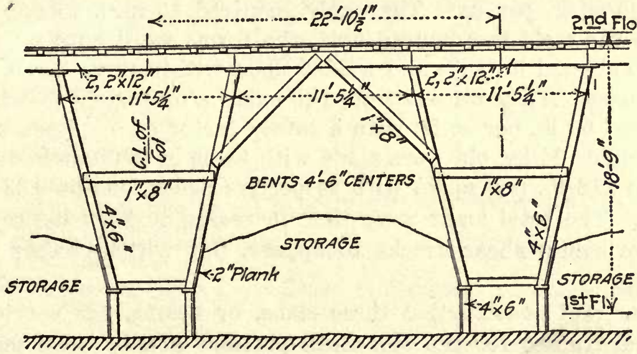
The diagram, Fig. 1, gives the width of the base of the neatwork for a factor of safety against overturning of exactly 2. Using a minimum footing projection of 6 in. at the toe and 1 ft. at the heel, the entire wall always has a factor greater than 2. The maximum compressive stress in the concrete is 90 lb. per sq.in., and the wall will be on the verge of sliding when the coefficient of friction is about 0.3.

The dead-load for the case of a surcharge wall is considered the same as in case 1. The live-load has been taken as 11,000 lb. per lin.ft. of track, distributed from the base of rail and end of tie as shown in Fig. 2, the limits of the distribution being the face of the wall and a line 6 ft. 6 in. from the center line of the track midway between tracks, assuming a second track 13 ft. from the first. The ratio of horizontal to vertical live-load pressure has been taken the same as for the dead-load. The portion of the live-load pressure uniformly distributed over the width b has been assumed as adding to the weight and stability of the neatwork, while for the entire wall the width $b + 1$ has been used. No distribution has been considered beyond the plane of the face of the wall, no matter what the length of the toe might be.

The horizontal-pressure diagrams are shown in Fig. 2, and the widths of the base of the neatwork for dead-load and live-load are plotted on the diagram, as are also the values for dead-load only. The factor of safety against overturning for the neatwork is exactly 2. The maximum compression in the concrete is 103 lb. per sq.in., and the wall will be on the verge of sliding when the coefficient of friction is about 0.3, as before. The limiting values for the height of wall have been selected so as to make the diagram general for all heights likely to be encountered. It is not intended, however, to indicate that gravity walls of the extreme heights shown could be economically built. For estimating purposes, the quantities for the higher walls would be on the safe side.

Forms Designed To Leave Storage Space

As the street had to be kept open for traffic, storage for 1250 yd. was provided in a building recently erected in Toronto, Ont.,



Wide Space Between Bents for Storage

by employing specially designed form supports. The use of bents with a wide space between them was made possible by unusual story-height of the first floor—18 ft. 9 in.—and the fact that there was no basement. The bents were 11 ft. apart at the top and 17 ft. apart at the bottom, this construction being carried over an area six bays wide and three bays deep. The fourth bay, in front of the aisles thus formed, served as a connecting passage, and bents were built lengthwise of it for the full width of the six bays. Teams would drive into any of the first five bays, dump and return to the street by way of the connecting passage and the sixth bay, which was used for return only.

Each storage space thus provided had a length of about 75 ft. and a width of 17 ft., giving a storage capacity of 250 yd. Two bays were reserved for sand, two for stone, and one for cement.

Gypsum Roof Slabs of 10-Ft. Span

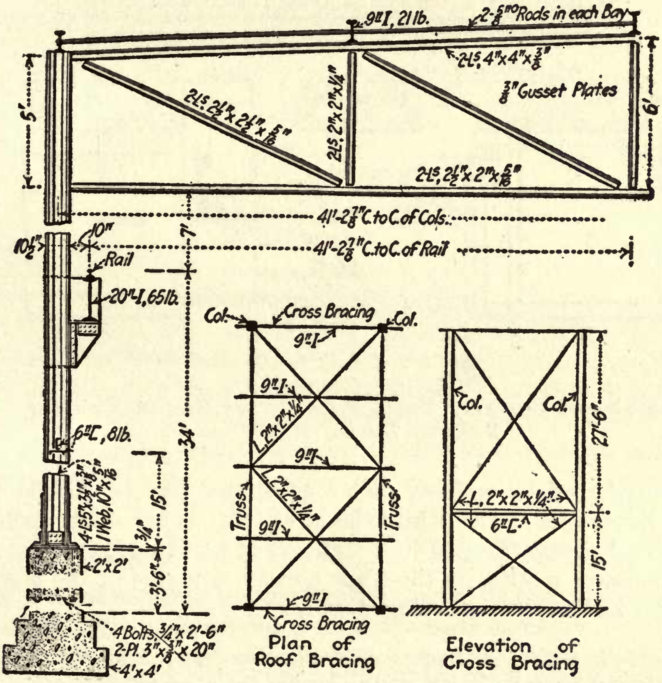
A roof covering composed of gypsum T-beam slabs 10 ft. long, having a clear span of 9 ft. 8 in., is a feature of a steel-frame building 190 x 200 ft. recently erected at Racine, Wis. These long slabs, designed as the outcome of numerous tests made at the University of Illinois, are of T-section, 15 in. wide and 8 in. deep, with a thickness of 1¼ in. for the top, or flange, and 2¼ in. for the rib. The ends are closed by diaphragms 15 in. wide and 2 in. thick. Each beam has two ⅜-in. rods in the bottom of the rib, one of these being bent up at the ends as a shear rod and looped so as to increase the value of the bond stress. In the top flange is embedded a steel-wire mat of No. 14 gage and 4-in. mesh. The weight is 16 to 17 lb. per sq.ft. The joints are plastered on the outer surface.

These beams were made at the site, in wood forms, at the rate of about 300 sq.ft. per hr. They only required 15 min. to set, from the time the mold was poured until the forms were knocked down, and were erected in place and walked upon within three hours after being poured. They were designed to carry a uniformly distributed live-load of 50 lb. per sq.ft. with a safety factor of 4. Tests of five sample beams 24 hr. old were made with loads of 2200 and 2400 lb., or 200 to 218 lb. per sq.ft., with respective deflections of 0.034 and 0.070 in. The total loads were then increased to 3500 lb., causing slight horizontal shear cracks to appear, but without other signs of failure.

In the roof construction these slabs, or beams, are carried by light steel trusses for the saw-tooth portions and by steel purlins, etc., for the flat portions, all of the supporting steel being spaced 10 ft. c. to c. In general the flat roof portion has a pitch of 1½ in 12, while the saw-tooth construction pitches about 7½ in 12. When a flat ceiling effect is desired, instead of the ribbed, or beam, ceiling formed by these T-beams, the slabs may be of H-section, with the top and bottom flanges of equal width. These weigh from 22 to 24 lb. per sq.ft. for the live-load noted above. In such a roof now being erected the beams weigh 22 lb. per sq.ft.

Crane Runway Columns Carry Roof

A yard crane with supports designed to carry a roof over the yard is an interesting feature of the new foundry plant for the James A. Brady Co., at Chicago. The material yard is between two buildings and is served by a 5-ton electric traveling crane.

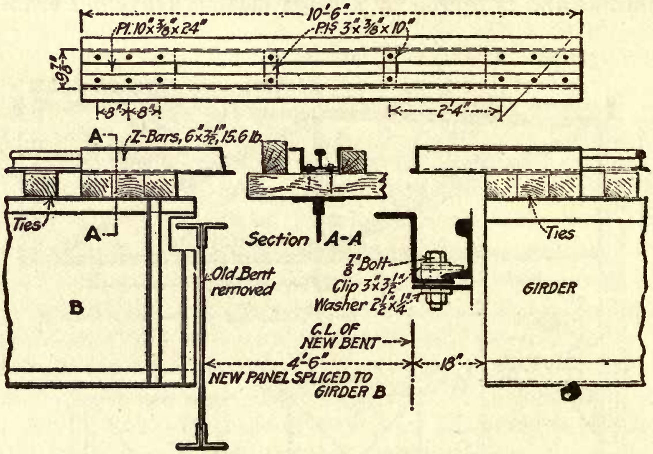


This Runway for a Yard Crane Is Designed To Carry a Roof

The crane runway consists of 20-in. I-beams carried by brackets upon columns about 42 ft. high. The runway is 180 ft. long, with columns and trusses spaced 20 ft. c. to c. The columns are of H-section, with a 10-in. web plate and four angles 5 x 3½ in. Longitudinal bracing is provided by a double line of 6-in. channels, forming an inverted T-section, between the columns, at a height of 15 ft. above the ground. Horizontal and vertical diagonal bracing is provided in three of the bays.

Temporary Stringers Carry Elevated Tracks

An opening 4½ ft. wide in the structure of the Metropolitan Elevated Ry., Chicago, was necessitated by changes in the bents and spans where the line crosses the new Union Station. One new bent was 4½ ft. from the old one, and the adjacent girder span had



Stringers Carrying Track Rails Across Gap in Elevated Railway During Alterations

to be lengthened by splicing on an additional panel. Traffic could not be interrupted; and while the work was being done, each rail was carried across the gap in a stringer of trough section, the ends of the stringer resting on the track ties at each side of the opening, as shown in the accompanying drawing.

Tar Paper Deadens Noise of Trucks

To deaden the noise from passing trucks rumbling over a concrete floor, a factory in Norwich, Conn., has successfully used a heavy tar paper pasted to the floor by paint. The method of application is as follows: The floor is first given one coating of a gray cement paint. On the following day, when the paint is thoroughly dry, a second coat is applied. At the same time one side of a fiveply tar paper is painted; and when both paper and floor are still wet, the paper is carefully laid wet side down on the floor and rolled with either a roller or wide-tired truck until all signs of air pockets beneath the paper disappear. The surface seems to improve with age and very effectively reduces noise at a low cost.

Excess Volume of Flared Column Heads

In computing the volume of the capital or flare in a column for girderless concrete floor construction, a simple method is to determine the volume of the flare outside of the column shaft, which is itself figured as running from the top of one floor slab to the bottom of the next slab above. Formulas for this additional volume have been deduced by Edgar H. Mosher, of Washington.

Where V = volume of concrete to be added to the volume of a straight column figured to the bottom of the slab; D, diameter of flare or top of capital, and d, diameter of column, the formulas are as follows:

For square columns,

$$V = \frac{(D - d)^2 (D + 2d)}{6}$$

For round columns,

$$V = \frac{(D - d)^2 (D + 2d)}{7.63}$$

For octagonal columns,

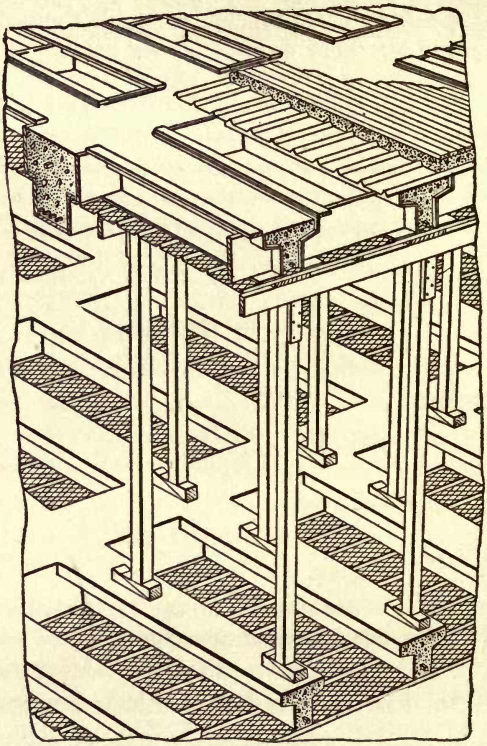
$$V - \frac{(D - d)^2 (D + 2d)}{7.23}$$

These formulas are deduced from the truncated cone formula, assuming 45° to be the slope of the flare.

Special Forms For Light Floor System

The designers claim a considerable saving in weight and hence in cost over any other fireproof floor of equal strength for a floor consisting of rows of small concrete beams or joists of T-shape poured monolithically with their supporting beams or girders between forms made up of spacing members or boxes of wood and cores of bent sheet metal. The accompanying perspective shows the general layout of the system, which may be used either on steel-frame or on reinforced-concrete buildings.

In building the floor, a line of struts is placed in each lower T-beam and capped with plank that serve as beam bottoms. On these plank as joists is then laid expanded or ribbed metal that forms a ceiling base. Then metal forms bent to the shape of one side of the T-beam are placed over each plank and held in position by properly cut brace boards between beams and by stiffener planks along the top. In the T-form thus made, the proper reinforcing is placed and the concrete poured to make the T-beam.

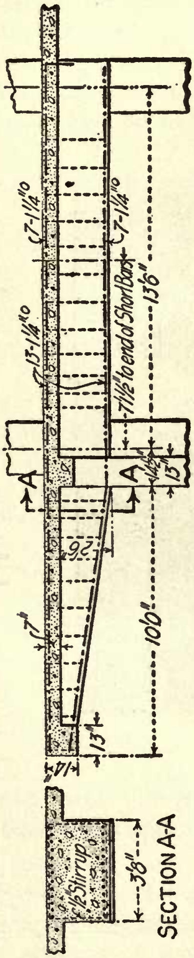


Perspective of Layout of System

When these beams have set, the bracing boards are knocked out and the beam metal forms released to be taken upward and used on the next floor above. The beams are then overlaid with another sheet of expanded metal, and the usual cinder concrete floor is placed. For the upper (floor) layer a fireproof board could be used in place of expanded metal.

Concrete Cantilever Beams

Cantilever beams of reinforced concrete, designed to support an outside entranceway leading from a bridge over the Fox River, and flat-slab floors without column capitals, to facilitate the placing of partitions, are two principal features in a recently completed eight-story hotel at Aurora, Ill. Above the cantilever entranceway for three panels of its length the mezzanine floor was also extended over the river on columns supported by the cantilever beams, the heaviest of which is here illustrated in detail.



Details of the Heavy Cantilever Beams

The building is 70 x 100 ft. in plan, with its main entrance on the south side and with a second entrance at the northwest corner, where the hotel adjoins the new bridge. This outside entrance, which is indicated by the photographs, cantilevers 10 ft. over the river, and results in saving space within the building lines to such an extent that one more store is now available which would have been eliminated if this scheme had not been adopted.

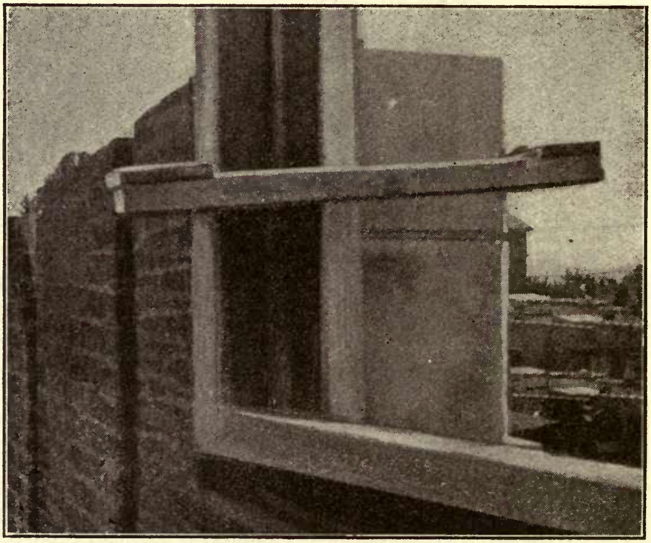
In order to facilitate the locating and rearranging of partitions, flat-slab floors supported on square columns designed to eliminate the column capitals usually used were adopted. The first-floor slab is 7 in. thick; the slabs used on the upper floors are 6 in. thick. No beams were required except the cantilevers already described and beams for window lintels and to frame around elevator and stair openings. The design of the slabs proved to be economical, four-way reinforcement of ½-in. rods being used.

The forms for the cantilever beams were also constructed as a cantilever timber framework, owing to the fact that the river bottom beneath the outer ends of these cantilevers consists of boulders, dirt and rubbish, making it impossible to drive piling on the shore.

Window-Frame Clamp Saves Time and Room

When setting window frames in stone or terra cotta faced buildings, considerable time can be saved, as well as avoiding the obstruction of floor space with long braces, by using the clamp shown in the photograph. The long piece is a 2 x 4 to each end of which is nailed at right angles a piece of board about 6 in. long. Five nails are used in each end. The distance between the inside edges of these boards is 1 in. greater than the distance between the outer face of the jamb and the face of the brick backing.

The window frame is set up when the first jamb stones have been placed, after which one of the braces is placed at each side.



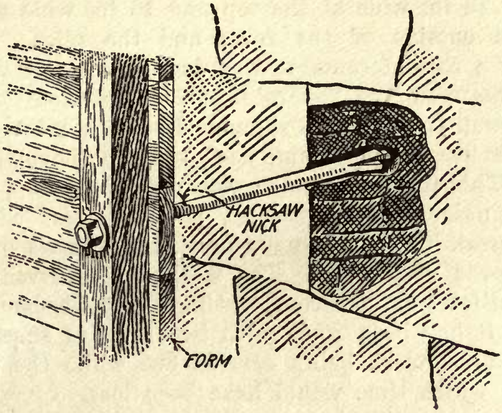
Clamp Can Be Quickly Adjusted

The braces may be tightened with wedges, or by driving down one side until the brace sets tight. They will hold the window frame securely in place until the brick work is finished.

Anchor High Form to Face of Stone Retaining Wall

Anchor bolts were used as shown in the sketch to secure the form for facing with concrete an old retaining wall of dry masonry which supports a section of a railroad line that runs along the face of a cliff about 100 ft. high. The wall extends down to a ledge about

50 ft. below the track. This ledge was about 10 ft. wide outside the old stone wall, and the working space was still further reduced by the thickness of the new wall, which was 4 ft. at the bottom and 18 in. at the top. The anchor bolts were of ⅝-in. round rods, one



High Form on Cliff Face Anchored to Old Wall

end of each of which was split for about 2 in. to receive a wedge. Holes 5 in. deep were drilled into the stone of the old wall, into which the split ends of the rods, with small wedges inserted, were driven.

As it was impossible to remove the bolts after the forms were stripped, they were nicked with a hacksaw about 1 in. inside the face of the form. When the forms were taken off, a few sharp blows with a hammer knocked off the ends of the bolts inside the surface, and the holes were plastered up.

Some Capital Things in Foundation Work

Use Pier Form as Inside Cofferdam

The pier-shaft form was set under water and did double duty as inside cofferdam and concrete form in constructing the shaft of the pier for the Division St. bridge in Spokane. The cofferdam had been sealed under water, and two layers of bracing, which had been required during the driving of the sheeting and the placing of the seal, were then removed. This work was done by a diver, taking out the crossbraces but leaving the tie-rods in place. The form for the pier shaft, which was built of 2 x 8-in.

tongue and groove sheeting, placed vertically, was stood up in the cofferdam, brought to line and well braced inside with the help of the diver. The cost of this form exceeded by a surprisingly small amount that of similar work done in the open.

The extra width of the cofferdam and the batter of the pier left a space 28 in. wide at the top and 16 in. wide at the bottom between the outside of the form and the piles. Around this space, about a foot of concrete was deposited under water, sealing any leaks between the concrete and the bottom of the form. This space was then carefully puddled with a mixture of gravel, clay and manure, gravel being used to save the clay, which was expensive. This formed a puddle-wall cofferdam for practically the cost of a single line of sheeting, plus the cost of placing the puddle material. Having tongue and groove walls on both sides, the dam proved very tight. The method also saved considerable time, the initial time for constructing the cofferdam being much less than if it had been made with two rows of sheeting, and the form and puddle work being carried out while the concrete seal was setting, which time would have been lost.

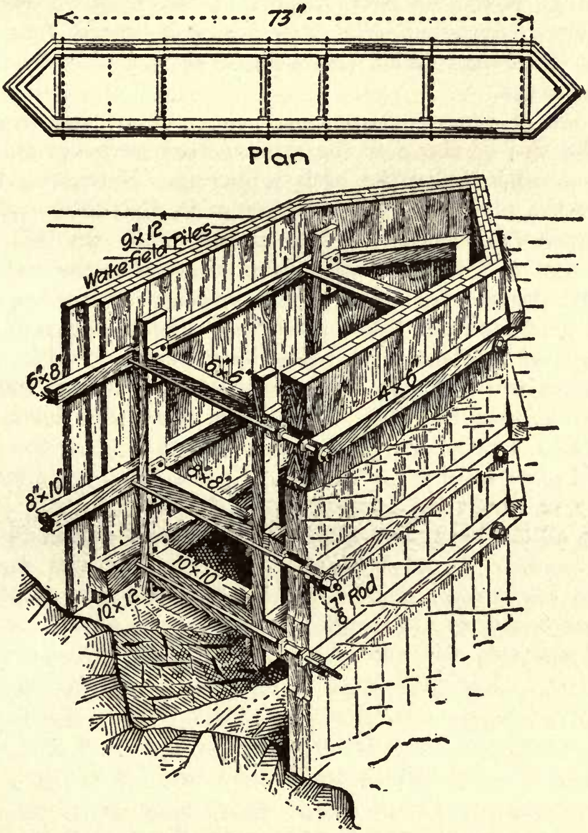
A pump was put inside the form, the space unwatered and the seal concrete carefully cleaned. The bracing inside the form was taken out as the pier concrete came up.

Cofferdam on Uneven Rock Bottom

A cofferdam of Wakefield sheet piles, which was framed and put in place as a skeleton before setting most of the piles, was used successfully on the practically bare and very irregular rock bottom at the site of one of the piers for the new Division Street bridge in Spokane.

This bridge was a structure 70 ft. wide and about 600 ft. long, consisting of three concrete arch spans with concrete viaduct approaches. The pier between the second and third arch spans was located in water which was 23 ft. deep at the lowest point, at low-river stage. Being only a short distance above the falls, there was a strong current at the bridge site. Soundings showed that the site of the pier was crossed diagonally by a vertical ledge, the bare rock at the downstream end of the pier being about 15 ft. below the water, while the rock at the upstream end, where the depth was greatest, was covered with 3 or 4 ft. of sand and fine gravel. It was planned to construct the pier on a concrete seal placed on the rock under water, and it was necessary to use a cofferdam because the irregular bottom made a crib out of the question.

The cofferdam, the skeleton of which was built in the water, towed to place and set before the insertion and driving of most of the piles, was made 2 ft. wider and 3 ft. longer than the base of the pier. Three layers of outside and inside waling, between which the sheeting fitted, were framed and spaced at the proper



Frame for Sheet-Pile Cofferdam Supported by Driving Down Slotted Piles

distance apart by bolting them to sheet piles placed at each cross-brace, 16 ft. apart. In these piles, through which passed the long bolts shown in the drawing, which held each layer of bracing together, were cut 1¼-in. by 4-ft. slots to permit driving them after the dam was placed. So that they would not bind after the frame had been drawn tight with the long bolts, 1-in. pipe sleeves, ½ in. longer than the thickness of the pile, were placed around each end of each long bolt in these slots. These sleeves, bearing against plate washers inside the rangers, prevented their being clamped tightly to the pile. The rectangular part of the frame was 12 x 73 ft. inside the sheeting, but the total inside length of the cofferdam was 89 ft. on account of the two pointed nose sections.

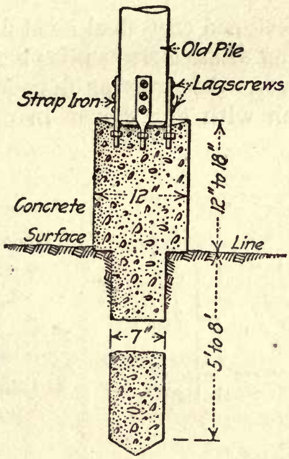
In addition to the posts shown in the drawing between the three tiers of bracing, the frame was X-braced for its entire length in a vertical plane, and each layer was also X-braced with 2 x 6-in. planks.

Pile bents, braced above and below water, had been driven out to the site of the pier for construction purposes and to serve later as a support for the arch centering. Extending the entire length of the pier and about 3 ft. from it, this falsework afforded a good anchorage along one side of the dam. On this falsework was a large stiff-leg derrick. The frame was moored and held plumb by the derrick while being weighted with bags of sand until it grounded on the downstream end. The upstream end was weighted to float level with the lower end, after which the slotted piles were driven, where the 4-ft. slots were long enough to permit it, to a bearing. These piles were then bolted securely to the frame, serving as legs to hold it in place while the remaining Wakefield piles were set around it. Special piles were made where necessary to secure tight closures.

When all the bays were filled, the piles were driven to rock with a drop hammer, handled in swinging leads by the derrick, and bolted to the frame, more weight being added to overcome the increasing buoyancy. The piles were built up of 3 x 12-in. plank, surfaced one side and one edge, and were dry when placed, so as to swell tight. The only openings were now the slots, the irregularities on the bottom, and in some cases a hole as much as 3 or 4 ft. high where the slots did not permit driving a pile to bottom. The large holes and slots were boarded up by a diver.

Concrete Bases for Old Bridge Piles

Replacing piling under wood bridges still in fairly good repair as to caps, joists and flooring has been one of the big items of expense in Sedgwick Co., Kan., for years past. The county is now doing a great deal of permanent bridge and culvert construction, but there are still many pile bridges over the larger streams which will have to be maintained for a number of years to come. To reduce this expense concrete bases have been placed under the piles that have rotted dangerously at the ground line. Replacing a pile always necessitates tearing up the deck of the bridge, removing at least two or three joists and frequently the cap, and sometimes requires falsework for the piledriver. Where it has been possible to work on the ground and there was soil that would stand, a repair gang has put in a concrete base, retaining the upper part of the old pile. The chief difficulty has been to get down past the root of the pile. This has been surmounted in most cases either by pulling or digging out the lower part of the pile, or by moving the top of the pile slightly.



Base for Old Pile

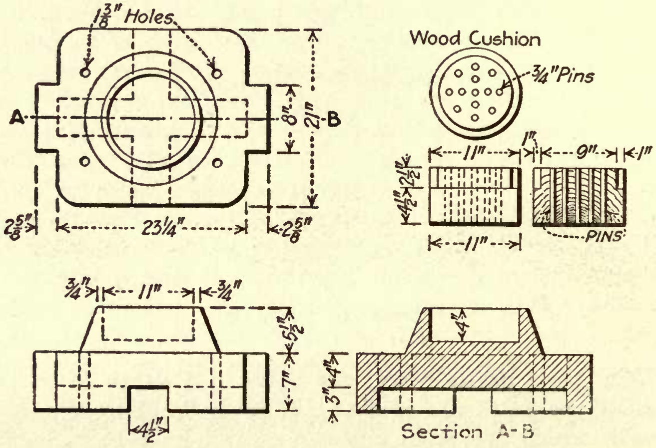
A 7-in. post augur drills the holes to a depth of 5 to 8 ft. Sometimes the holes are reamed out by a "jabbing digger" or a pile spade, which operation allows a mushroom base to be formed. Where shale or a very hard clay subsoil is encountered—even though only a few feet under the surface—no attempt has been made to penetrate it; nor have these holes been put down or bases built where there is surface water. In a number of instances where sand was struck below the surface, this sand was thoroughly mixed with a sackful or less of cement, thus forming a base that holds satisfactorily. This construction, however, is never attempted except where the surface soil is firm and hard.

After filling the hole with concrete, a round sheet-metal form, a little larger in diameter than the hole, is placed at the surface. In the form three or four iron straps are placed, so that they will project 8 to 12 in. above the concrete. Each strap is drilled for two lagscrews, and the straps are placed so that the pile slips between them.

The top of the base is pressed down or cupped, using either a wood form or a trowel. This device helps to keep the pile firmly in place. The concrete sets for 48 hours before the pile, which is secured with the lagscrews, is placed. Under favorable conditions this method of repair is much cheaper than replacing old piles with new, and it seems to be more lasting.

Cushion Blocks Reinforced by Vertical Rods

With a specially designed cast-steel hood fitted with a reinforced wood plug rapid driving of steel sheet piles has been accomplished at Dam No. 39, Ohio River. As many as fifty-four 25-ft. Lackawanna piles have been driven with one driver in one 8-hour shift. The



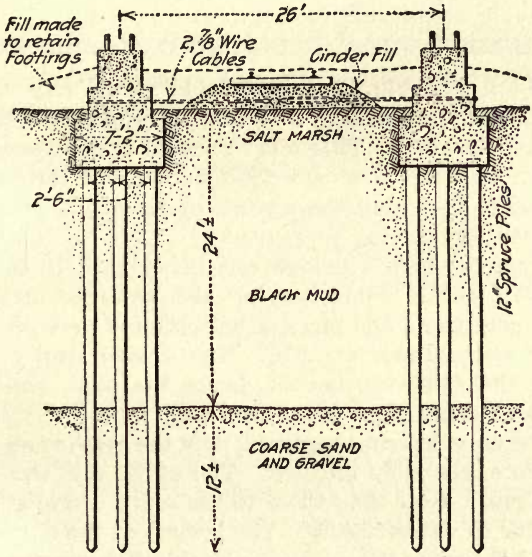
Round Pins Transmit Blows and Save Cushion Block

hood is so constructed that either straight web, gusset, corner or T piles can be fitted into the grooves in its under side. It is held to the hammer by wire lines or by rods passing through 1⅜ in. holes.

A circular hole in the head permits an oak block to be inserted as a cushion to receive the direct blow of the hammer. This block, 11 in. in diameter, is bound with a 1 x 2½-in. iron collar. This prevents it from mashing up at the top. Holes are drilled in the block to receive ¾-in. round iron pins which transmit the blow from hammer to pile follower.

Spreading Piles Pulled Back By Turnbuckles

The column footings for the three-track elevated railway along Stillwell Ave., Brooklyn, N. Y., were constructed across a swamp in which the mud varied in depth from 15 to 30 ft. The piers were supported on spruce piles 30 in. on centers, which were driven to refusal with a 2000-lb. drop hammer into the sand and gravel underlying the mud.



Spreading Footings Restored by Turnbuckles

Over the greater part of this swamp there was an ash fill 6 or 8 ft. in depth, which had been in place some 6 years. This fill served to give lateral stability to the footings. At one point, however, near a creek, there was no fill on the original salt marsh. Here it was brought home forcibly to the engineers that piles driven in soft material, although able to support the load brought upon them, have little lateral resistance, and that a structure supported on piles under such conditions is liable to injury if a horizontal force is brought to act on them.

The piers at this point are 7 ft. 2 in. by 9 ft. 8 in. in plan, supported by 12 piles each; they carry a load of 145 tons. The contractor laid a standard-gage track on a cinder fill about 2 ft. deep between the two lines of piers, and used a 50-ton locomotive and flat-cars to haul structural steel. The load of 35 tons per car axle which was thus brought to bear on the underlying mud forced it out laterally against the piers. It sprung the piles and spread the opposite piers apart 2½ in. in the bent in question.

In order to repair the damage, two ⅞-in. wire cables with turnbuckles were passed around the piers. By drawing these up, it was possible to pull the piers back to correct position. An earth fill was made around the footings to retain them in their proper position, the cables being left in place as an additional precaution.

Freezing Ground Acts Like Hydraulic Jack

Some 16-ton concrete piers in a Middle-West city were heaved this past winter by as much as 3 in. and subsequently settled back to their original elevation. This most unusual and extreme condition cannot be explained by ordinary frost action, but can be accounted for by the piers becoming the pistons of hydraulic jacks in which frost produced the moving pressure.

This occurred where a bridge was being built in the course of track-elevation work. Some heaving also occurred at an adjacent street. The abutments and piers at both streets were poured during the summer and autumn of 1916. The bridge steel could not be placed until the following season, hence the piers and abutments carried no load other than their own dead weight.

Where the most heaving occurred, only the center and south rows of piers were appreciably affected. The north row was fairly well drained and much drier than those to the south where all conditions were favorable to waterlogging. The bottom of the north side piers was about 4¼ ft. below the ground surface, of the center piers 4 ft., and of the south piers 3½ ft.

The discovery was made in March, 1917, that the south row of piers had heaved by amounts varying from 0.07 to 0.22 ft. The center row showed heaving ranging from 0.01 to 0.09 ft. The north row showed nothing in excess of ¼ to ⅛ in., most of which could have been in the original setting.

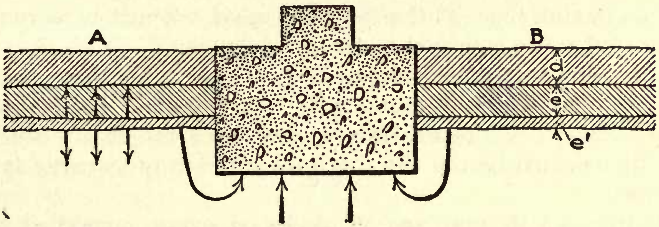
After this was discovered, levels were taken at intervals of 3 to 5 days. As the ground thawed the piers settled back into position until the highest corner of any grillage was but 0.06 ft., or ¾-in. above what it should be. A settlement of as much as 0.18 ft. or 2⅛ in. is shown.

The usual explanation would be that the frost penetrated to a level below the bottom of the piers and heaved them by direct action, but this does not seem adequate for the following reasons:

(1) It is very doubtful if the frost penetrated as low as the bottom of the piers.

(2) If the frost did penetrate to below the bottom of the piers there could not have been more than from 6 in. to 1 ft. of frost at the most. This thickness of frost could not possibly heave a pier nearly 3 in. Water expands about $\frac{1}{10}$ of its volume upon freezing. The expansion of water-soaked soil would not be greatly in excess of this if as much. That would mean but 0.1 ft. upheaval for a whole foot of frost under the pier.

If the pier is considered analogous to the piston of a hydraulic jack and the water or semi-fluid mud is forced under the pier by the pressure from the freezing expanding strata nearer the surface, the action can be understood.



Piers Were Plungers in a Big Natural Jack

Let *AB* represent the surface of the ground. Suppose the ground to freeze to a depth *d*, such that the frozen layer becomes rigid and unyielding. Let the frost then penetrate to an additional depth *e*. The layer *e* expands in freezing. It exerts a pressure both upward and downward. The frozen mass *d* is unyielding and if the weight of the pier is less than the force required to break the rigid layer, the water and semi-fluid clay will be forced upward like a piston. Such an action would account for any amount of heaving.

At the other location, where there is practically no depression, only 3 or 4 piers out of a total of 42 were found to have been raised. The heaving varied from ⅜ in. to 1¼ in., only one pier having been heaved the latter amount. But at this street no pier bottom was less than 5½ ft. below the ground surface. It is certain that frost did not penetrate to that depth. It is unfortunate that test borings for depth of frost penetration were not made at both streets in order that more exact information might be had on this point.

Locomotive Tows Caissons to Place

The caissons launched for the bridge at Moncton, N. B., were quickly and easily towed to place by a locomotive at slack tide and moored before the treacherous currents of the Petticodiac River had an opportunity to carry them away.

When the first caisson was completed, it was lowered by jacks to sliding ways of 12 x 12-in. timber 24 ft. long. Each of these ways rested on one of the four main ways, which were spaced on 14-ft. centers under the caisson, giving an overhang of 13 ft. at each end. The main ways, which were braced and blocked continuously, had a slope of about 1 to 9 and were run into the ground at the lower end to prevent their sliding. The struts between the main ways were weighted with rails to keep the ways from floating at high water. The forward ends of the sliding ways were also weighted with rails to sink them as the caisson floated, when they were pulled clear by lead ropes attached to their rear ends.

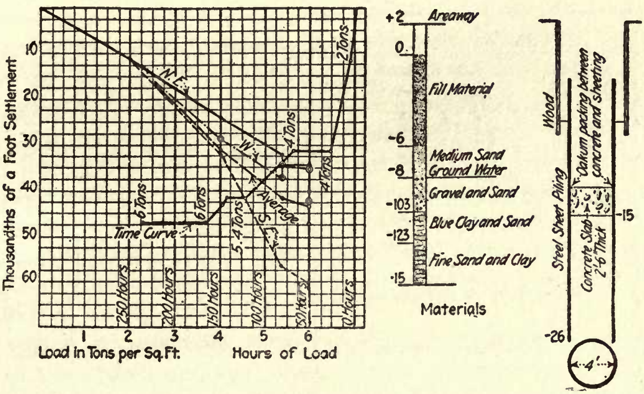
The caisson was launched one hour before high tide, while the current was still running in slowly. As expected, it reached the end of the ways before floating, giving time to get a 1¼-in. steel towing line aboard before the tide rose sufficiently to carry it clear of the ways.

This line ran through snatch blocks on scows moored at pier 3 and at the site of the caisson, and was led from there to a third sheave in line with a siding on the opposite shore, where the line was attached to a switch engine. As the caisson floated, the locomotive started slowly, pulling it over to the first scow at pier 3. The shackle pins on the mooring lines of this scow were knocked out and scow and caisson together hauled over to the second scow. The latter, moored near the location of the pier, had on board the anchor lines up and down stream. These were quickly transferred to the caisson, which was then dropped downstream to approximate position. The entire operation was completed before the outgoing tide interfered.

Bearing Test on Confined Wet Sand

A concrete slab-and-girder mat, with the wet treacherous sand underneath confined by a ring of interlocking steel sheet piling, supports the new boiler house and coal-storage plant of the New York Steam Co., at Burling Slip and Water St., in downtown New York City. The load of the boiler room averages 2.6 tons per sq.ft. of the entire foundation; for the coal-plant mat the load is 5.4 tons. Before the Building Department would permit such a foundation to be laid, it had to be convinced by tests of the safety of the method. The sketch shows how the loading test was made and gives the settlement by curves.

The test arrangement is really a model of the foundation proposed. A steel sheet-pile box was driven to a depth of 26 ft. below curb and the material inside excavated to a depth of 15 ft. A concrete slab 2½ ft. thick was placed on the sand bottom below



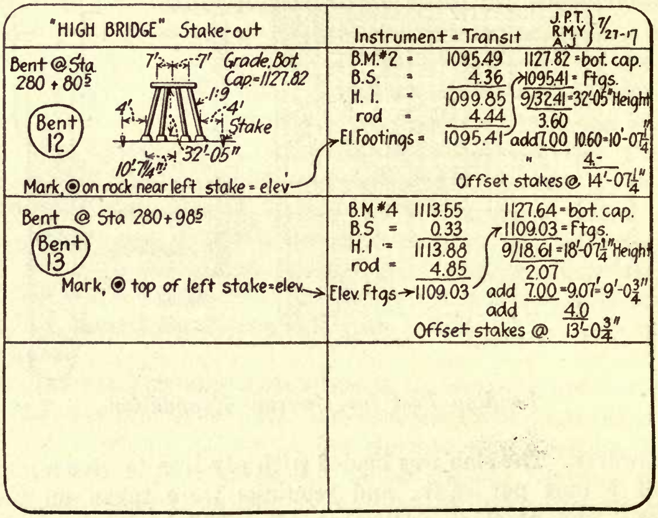
Loading Test for Unusual Foundation

groundwater. The slab was loaded with pig iron to give a maximum load of 6 tons per sq.ft., and readings were taken on the four corners. The greatest settlement after 237 hours was 0.061 ft., the average settlement for this period being 0.047 ft. The time curve shows that there was no settlement between load applications.

New Ideas in Designing and Building Bridges and Dams

Clear Form of Notes for Bridge Stake-Out

The following form of note keeping for stake-outs of bridge bents has been found simple, quickly made and of ready reference



Record Bridge Stake-Out Operations in This Manner

on the job. If the bridge is on a grade, it is necessary to have available, preferably in the same notebook with the stake-out records, the information indicated in the accompanying table.

DATA ON "HIGH BRIDGE"

Station	Bent No.	Grade (1%) Floor Surface	Grade (1%) Bottom of Cap
280 + 80.5	12	1129.82	1127.82
280 + 98.5	13	1129.64	1127.64
281 + 16.5	14	1129.46	1127.46

With the above data and benchmark levels readily accessible, the staking out of the bridge bents is undertaken, and the operations so performed are recorded in the manner suggested by the illustration of a typical field notebook opening.

Temporary Hinges for Concrete Arches

The common assumption that, with an arch curve laid out to conform to the dead-load equilibrium curve the dead-load produces no bending moments in the arch, is materially in error. This error arises from the arch shortening produced by the dead-load compressive stresses and is similar to a fall in temperature; it results in a reduction of the horizontal thrust, with a consequent divergence of the true pressure line from the assumed arch axis. The pressure line then passes above the axis at the crown and below the axis at the springing, thereby increasing the compression in the outer fibers at the crown and in the inner fibers at the springing.

The magnitude of the foregoing error depends upon the proportions of the arch. It may be neglected in arches having a rise greater than one-fourth of the span; but in flatter arches it becomes increasingly serious. From some designs that have been worked out, in which the depth of rib was uniformly 3% of the span length, it appears that the addition to the dead-load stresses on account of rib-shortening may attain considerable magnitude, especially in the flatter arches.

A method of avoiding these additional stresses is to provide hinges at the crown and springing during the erection of the arch. Temporary hinges were employed by the late George S. Morison in the construction of masonry arches; they have also been used in a number of European bridges. These hinges should be closed by pouring concrete into the joints only after the full dead-load is on the structure and the shortening and shrinkage changes have taken place. By selecting the temperature for closing the hinges, the range and effect of the subsequent variation may be minimized.

The above advantages of the three-hinged construction apply mainly to the conditions during erection. For the finished structure, a hingeless type is to be preferred on account of the greater rigidity and the greater security against crown settlement. Temporary hinges eliminate the shrinkage stresses without involving the difficulty in the construction of bulkheads caused by interference with the steel in the case of reinforced construction.

Circular Curve for Arch Design

In laying out an arch curve for the first trial design, a simple circular curve is ordinarily satisfactory. With this curve drawn, the weights of the arch segments and superimposed filling are figured and the resulting equilibrium curve constructed. With this pressure line as a new arch curve, the deadloads may be revised and a second equilibrium curve drawn; as a rule, however, the first curve may be retained without the revision of a second trial.

For ordinary concrete arches with earth-filling up to a level line, the ideal arch curve will be found slightly higher at the haunches than a simple circular curve. The following table gives the amount of this deviation, as found from actual designs, for different rise-ratios:

Ratio of Rise to Span	Deviation from Circular Curve at Haunches, in Per Cent. of Rise
0.25	4.3
0.20	4.2
0.15	3.7
0.10	3.5
0.07	3.1

In the flatter arches, the deviation from a circular curve is barely noticeable.

Theoretically, the ideal arch curve is the equilibrium curve for the dead-load plus one-half of the live-load covering the full span. This curve would be the exact mean of the two extreme curves obtainable by placing the live-load alternately on the two halves of the span. In practice, however, on account of the usual small ratio of live- to dead-load, there is no material difference in using the equilibrium curve for dead-load alone.

Approximate Methods for Arch Design

The elastic theory when applied to arches with fixed ends is not only time-consuming, but is essentially a method of analysis and not directly of design. Hence there is a real need for satisfactory formulas or methods for determining approximately the crown thickness and the proper form of the arch ring. It is necessary in order to determine the stresses to assume the dimensions of the arch rib. Experience must be the main guide in this primary assumption, and the designer has two classes of aids:

1. *Emperical formulas,* which are crystallized expressions of past experience;

2. *Approximate methods,* by which crown thrusts and lines of pressure may be determined.

Formulas of the first class are the modern representatives of the experimental proportions which probably guided the ancient arch builders. Methods of the second class are an outgrowth of the line of pressure theories developed for voussoir arches, and are an improvement over class 1, principally in that a greater range of conditions can be considered, and that more particulars of the form of the arch can be determined by their use.

Joseph P. Schwada has developed formulas for the thrust T and the depth d at the crown in terms of a coefficient K representing the ratio between the average crown stress and the maximum stress in the arch. The following equation has been derived for the thrust, based upon the assumptions used by Mr. Schwada, but using the general formulas derived by C. Tourtay in 1902. In Mr. Schwada's notation:

$$T = \frac{L^2}{R - d}\left(\frac{B + w}{8} + 2.28R + 17.61d + 15F\right)$$

This equation gives slightly lower values than Mr. Schwada's equation, all terms being identical except those in the parenthesis containing R and d. The depth at crown is

$$d = \frac{T}{144 f_c K}$$

Mr. Schwada presents a valuable series of diagrams and tables for the value of the coefficient K, and for the solution of his equations.

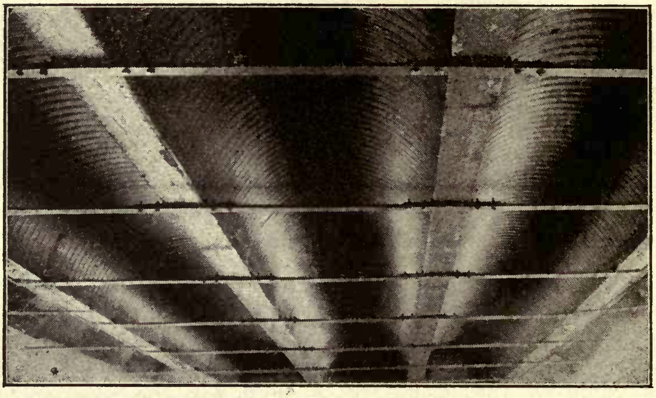
The process of the design of an arch ring is then as follows:

1. Tabulate the general conditions which can be at once determined or assumed, and the known factors such as span, rise, loads, etc.
2. Make a rough assumption of the crown and springing line thickness (possibly using a formula of class 1).
3. Compute the value of thrust T, and if necessary correct the assumed crown thickness.
4. Construct a line of pressure with horizontal thrust (pole distance in the force polygon) equal to T.
5. Choose a value for K which will suit the type, the rise, and the span of the arch, and compute the value of the crown thickness d.
6. Choose a curve for the arch axis which will fit the line of pressure constructed as in 4.
7. Vary the thickness of the arch and place the reinforcement in accordance with the thrusts shown in the force diagram, but making proper allowance for the effects of moving loads and temperature.
8. Analyze the arch thus determined by the elastic method.

It will be found that a very close approximation to the best design is determined by the first seven steps, and only minor changes may be expected from the full elastic analysis, while the labor is far less than a preliminary analysis by the elastic method.

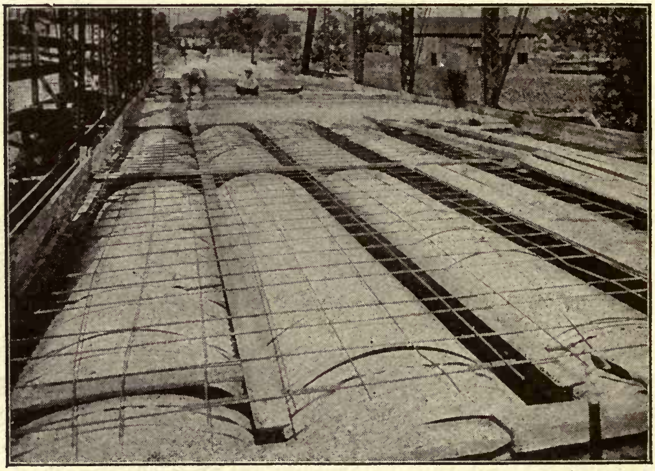
Culvert Pipe Used as Basis for Floor System to Bridges

A reversion to an old system of highway bridge floor, with some modern variations, is seen in the use of corrugated iron culvert



Underside of Colorado Bridge Floor Where Culvert Half Rounds Are Used as Forms

pipe forming the basis for concrete arch floor spans. In the old designs light gage corrugated steel in the new type half sections



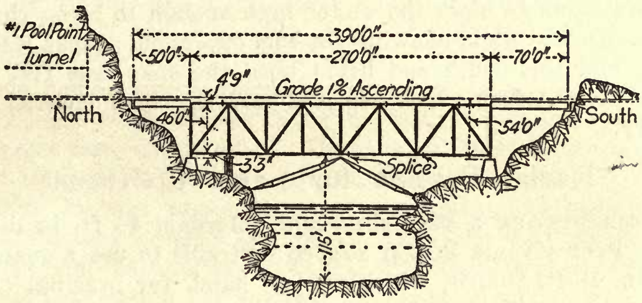
Concrete Floor of Ohio Bridge To Be Placed on Culvert Sections as Forms

of heavy-gage culvert iron is used, with additional reinforcement of the concrete floor against expansion.

One view shows such a floor as installed on a through-truss bridge in Hamilton County, Ohio. For this bridge the culvert forms span between the bottom flanges of I-beam stringers which are framed into floor-beams. The other view shows the under side of the floor of a deck-girder bridge at Boulder, Colo. Here the main girders, 41-ft. span, are of reinforced concrete and the floor, a concrete slab reinforced against expansion with $\frac{3}{4}$-in. rounds on 10-in. centers in both directions, is poured on half-culvert sections spanning steel 24-in. I-beams which are spaced 4 ft. apart and placed parallel to the main girders and span between the abutments. In this bridge the I-beam stringers are stiffened by cross-braces of steel bars, as shown.

Bridge Erected With A-Frame

An example of the solution of a difficult erection problem through taking advantage of the exceptional natural conditions is seen in the methods adopted in the case of the Pool Point Bridge on the Elkhorn extension for the Carolina, Clinchfield & Ohio Railway. This bridge crosses a deep basin in which there is always from 50 to



Center Support Was Provided for Cantilever Erection

90 ft. of water. The stream is of torrential character, and above the site of the bridge is a splash dam which at times discharges large numbers of logs which would carry out any ordinary falsework.

These special conditions made it impracticable to use falsework of the usual type. The character of the rocky side walls suggested the use of an A-frame or arch type of center support and cantilever erection from the north shore for the 270-ft. main truss span. This design was therefore made of the riveted type, with provision for compression in the lower chords and proper sections throughout for cantilever erection beyond the center-panel point. The A-frame legs were made of derrick booms.

The main truss span of nine 30-ft. panels, 270 ft. long, flanked on the north by a 50-ft. girder span and on the south by a 70-ft. girder span is composed of two trusses spaced 19 ft. apart on centers. The main span weighs 613 tons, and the order of procedure in erection was as follows:

The end post and 50-ft. plate girder span having been erected by the derrick car, the car could be advanced and the first panel placed with a temporary wooden bent at panel point L_1. The car was then advanced and the A-frame legs were placed on the north side and held in position by guys. Following this, lines having been passed to the other bank, the south legs of the A-frame were swung.

The shore ends of the A-frame had cast-steel bolsters supported on concrete skewbacks and the tops were provided with cast-steel shoes for supporting the truss. The A-frame being in place, the remaining panels up to the center were erected, the splices being located as shown on the diagram, and the center panel point blocked up on top of the A-frame. From this point cantilever erection proceeded regularly panel by panel until the shoe at the south end had been placed.

The deflection of the cantilever end was about 8 in., and care had been taken to block the center high enough to bring the south end about a foot high, allowing for this deflection. Jacks were then applied and this south end lifted until the span was free at the center. The A-frame was removed and the span lowered to the masonry.

Radial Bracing for Large Cofferdam

In constructing a steel sheet-pile cofferdam 46 ft. in diameter for the Pennsylvania R.R. it seemed desirable to use a quantity of 8 x 16-in. 18-ft. timber, which was on hand, for bracing. As the distance across the cofferdam was more than twice the length of the timber, a wood pile was driven in the center of the cofferdam before excavating; and a "hub" supported by this pile was constructed. Excavation has been carried 18 ft. below water level, and two sets of waling and struts have been placed in this manner. The method has been very successful.

Forms Have Sliding Cantilevered Studding

Cantilevered vertical studding which does not have to be taken down to set the next lift of forms is used to support the forms for La Loutre dam, being built on the upper St. Maurice River. By the use of such supports the interior spaces where concrete is being deposited are kept clear of all tie rods. Two pieces of timber on edge are held parallel and 1 in. apart, being double bolted through a space block at the upper end. This arrangement gives a slot the whole length of the support, so that it can be slid vertically upward for another lift of concrete. In this respect the scheme differs from previous forms of same type.

The holding bolts are tightened when the form and support are in place for proper alignment. If there is any overhanging, the heel or lower end of the support is blocked outward. Form framing here is horizontal and lagging is vertical.

Holding bolts 1 in. in diameter are spaced at 2-ft. intervals. The bolts are wrapped in a sleeve made of paper which has been dipped in tar and dried. At the inner end is a 3 x 3 x $\frac{5}{16}$-in. plate. Very little difficulty has been found in screwing the bolts out. Large square washers at the end span both timbers of the support.

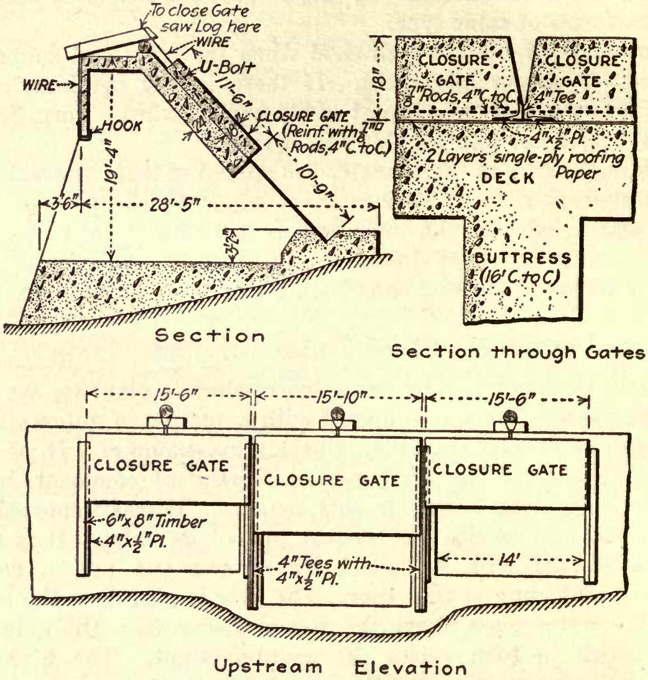
Automatic Flood Gates for 17-ft. Dam

The 17-ft. concrete dam for a hydro-electric plant on the Cedar River at Nashua, Iowa, is equipped with a number of automatic flood gates each 46 ft. long and holding back a maximum of 7 ft. of water. The installation of the flood gate is worthy of comment, because this particular type is new to this country. It was imported from Switzerland and service has already proved its value. It is simply a walking-beam with a gate hung at one end and a concrete counterweight hung at the other. The gate is hinged at the bottom. When the water rises above the required elevation, the gate turns down, which in turn raises the counterweight. The higher the water the farther it opens the gate. When the gate opens, the leverage between the counterweight and fulcrum increases and that between the gate hinges and fulcrum decreases, thereby overcoming the increased weight of water at every stage of gate opening. Gravity and constantly shifting leverage are its features. The gate is of steel and was entirely fabricated and set before grouting in.

Creosoted plank was used for decking, well bolted on. Leaking around the ends was prevented by a leather bearing on the concrete. A leather bearing on a curved plate prevented leakage over the hinge where the gate fastened to the rollway. The counterweight was formed and poured in place, being shored up from the crest of the dam.

Concrete Closing Slabs Slide to Place

On the construction of the dam at the new hydro-electric plant at Hiram, Me., on the Saco River, water was allowed to flow through the dam during the main building period, three openings being left in the lower part of the deck. Closure was then accomplished by three reinforced concrete gates which were cast upon the deck of the dam as shown and each held in position by a wire rope attached



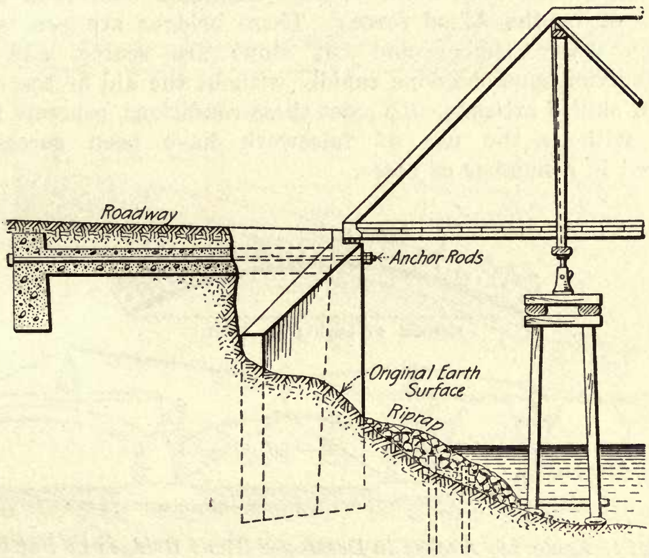
Slabs Slid Down Deck of Dam on Greased Tarpaper To Make Closure

to log anchored under the opposite wall of the dam by a second rope and hook. Each closure gate was reinforced both ways with $\frac{7}{8}$-in. square rods spaced 4 in. on centers and was provided with a U-bolt by which the wire attachment was made. To prevent adhesion between the closure slabs and the deck of the dam, two layers of single-ply roofing paper, greased between layers, formed the base upon which the concrete was poured. The closure gates were about 16 ft. high, 18 in. thick and 15 ft. wide, sliding downward between guides composed of 4-in. tees flanked by 4-in. by $\frac{1}{2}$-in. plate on each side. By sawing off the log above each gate on the top of the dam the slab was released and slid into place seating against a concrete recess at the bottom of the deck, as shown in the cross-section.

Slipping Bridge Abutment Saved

A casual inspection of the 100-ft. steel highway bridge which was built some time ago without engineering supervision showed that the anchor bolts were bent and the shoes were pressed tightly against them. There was no information available as to the exact location of the abutment or as to the batter of the faces, but it was very easily seen that one of the abutments had moved. An investigation indicated that while one abutment rested on hardpan or rock, the other—which is about 18 ft. high above water level and of unknown depth below—probably rests on a fine sandy loam. The stream channel shifting had eroded this deeply.

To prevent further erosion, two lines of piles were driven near the toe of the slope and the whole slope covered with a heavy riprap of stone. Holes were drilled through the abutment near the juncture of the wings and face, and 1½-in. rods, 34 ft. long, were



Abutment Retained by Concrete-Incased Rods Passing Through Concrete Deadmen

placed in trenches running back along the roadway. These rods were incased in concrete for their entire length and anchored to concrete deadmen at the end.

To further strengthen the abutment, a narrow trench was dug along its back and filled with concrete—the extra width providing sufficient breadth to receive the bearing when it was replaced in its proper position.

When the concrete at this point was hardened sufficiently, the nuts were tightened on the tie-rods, a new anchor bolt hole drilled and the bolt grouted in. To lift the bridge while widening the seat beams, struts made of pine logs flattened on two sides were attached at the first panel points, as is indicated in the line drawings. A beam rested on top of these struts and passed under the top chord. The bottom chords, stiffened by means of 4 x 6 timbers inserted between the floor-beams, completed the provisions against reversed stresses.

Arches Destroyed by War Replaced Quickly

The exigencies of battle in the north of France have required the rapid and stable reconstruction of a number of masonry arch bridges that had been more or less completely destroyed by the German or by the Allied forces. These bridges are generally in an area where timber and cut stone are scarce, and their reconstruction must be done rapidly without the aid of the needed quota of skilled artisans. To meet these conditions, concrete arches placed without the use of falsework have been successfully employed in a number of cases.

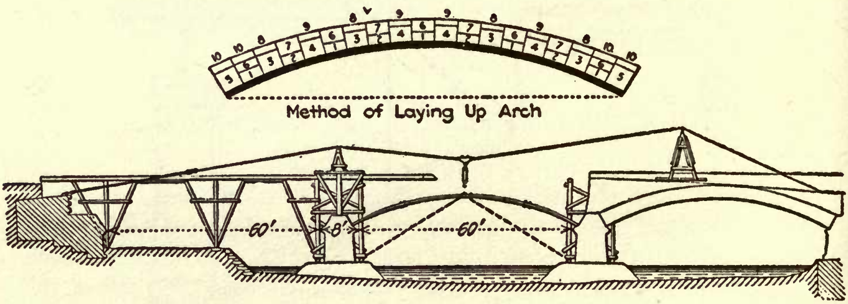


Fig. 1. Restoring Arches in Destroyed Stone Bridges in Battle Area of France

Cement can more readily be brought forward than any other structural material, and sand and gravel are local products, so that concrete, which can be made by unskilled labor, is doubly effective for such work. A novel feature of the reconstruction is the use of old iron and a minimum of timber for arch centers, which can be readily erected, thus saving time and labor.

The first operation in the reconstruction of one bridge was to build the light timber framework carrying the footway and erect thereon the towers for a construction cableway. From this cableway a series of centering ribs made up of old steel rails was placed. These rails, which were found in the neighborhood, weighed 60 lb. to the yard. They were cold bent to the proper curve, in two sections and spaced 20 in. c. to c. clear across the arch. At the abutment they were bolted to a bedplate that was held by a hook bolt driven into the masonry. These curved rails were used as the basis of a thin concrete arch that in itself served as the center for the main arch. This procedure was adopted rather than placing the main arch immediately upon falsework hung from the steel ribs themselves, because the rails were not sufficiently strong to act as centers.

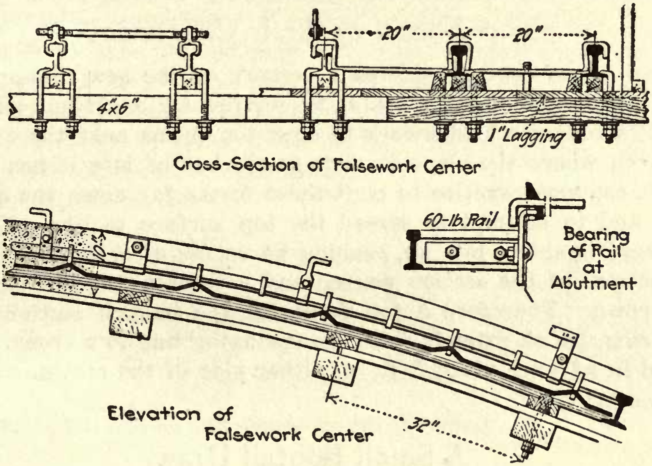


Fig. 2. Details of the Steel-Rail Arch Centering Used on Meurthe River Bridge

The centering consisted merely of timber joists and a floor. This concreting was done in two parts, a 1:2:4 concrete was placed for its uniform thickness of 10 in. from abutment to abutment, and for the full width. On this a concrete arch rib and two abutment sections were first placed and the intermediate sections last. The concreting of this shallow section could be done in one morning. Ten days was allowed for this concrete to set. Meanwhile the top of the rib was laid off in 19 voussoirs, and a vertical dividing wall was erected across the arch at each voussoir division line. This dividing wall was made of a wire mesh, large enough to hold the aggregate, fastened to $\frac{3}{4}$-in. and $\frac{5}{8}$-in. vertical rods tied in at the bottom to hook bolts that had been left emerging from the centering concrete. These frameworks having been placed during the 10 days allowed for the setting of the centers, concreting was carried on across the arch rib in the voussoirs so laid out, placing them across the bridge so as to impose the least eccentric loading on the centering arch. The progress of voussoir deposition is shown. All this concreting for one 6-ft. arch could be done in two 10-hour days.

After the main arch rib has achieved á sufficient set, the centering arch can be removed, although this is not necessary. Meanwhile, the superstructure of the arch can be erected in a continuous process following the construction of the main arch rib, and the roadway put into service in a minimum of time.

Top Forms in Arch Concreting

Top forms were considered necessary on the new Chesapeake & Ohio Northwestern Ry. work at Sciotoville, Ohio. It has long been usual in concrete bridgework to omit top forms near the crown of the arch where the slope is very small, but of late it has become rather common practice to omit these forms far down the arch rib slope and to attempt to screed the top surface to line. Concrete so placed is apt to pile up, causing an excess of arch-ring depth at the bottom of the section poured and a thinning of the ring near the crown. Therefore a top form for the haunch section of the arch ring, which extends from the springing line to a crown section placed in advance about 3 ft. on either side of the crown, was used on this bridge.

A Small Bobtail Draw

In building a swingbridge across a neck of Lake Lucerne at Stansstad, Switzerland, for 22 m. clear opening, the engineers for the Canton Nidwalden adopted the bobtail swing type but detailed it in such manner as to make substantially a single-leaf swing. The short arm ends just beyond the turntable, so far as the bridge floor is concerned. It extends out under the approach floor, however, as counterweight for the long arm. The approach deck over this counterweight has supports at one side only, the other side being left clear to allow the counterweight to swing out. The result of this arrangement is that rocking action due to live-load on the short arm is nearly eliminated, making it possible to dispense with wedging or tight latching at the outer end of the long arm, as well as with bearings under the short arm. The operating machinery is thereby simplified, and the required power reduced, which (the bridge being hand-operated) means that the time required for opening and closing is reduced. The end of the long arm has one lower and two upper track-wheel supports, and these enter between tracks inclined slightly upward, as the bridge closes. There are also two flat bearings, one under each girder, but they are adjusted to be barely in contact when no live-load or wind is acting. The turntable is center-bearing and has two side wheels and two at the quarter-points nearest the channel.

Field Determination of Bridge Skew

In reconnoissance work for ordinary highway bridges no great accuracy is required in determining the skew; even a variation of 5° being seldom important. A method of determining this skew in the field is to take an ordinary 6-ft. rule, hinged about its 3-ft. joint, place one arm in the line of the road and the other arm in the line of the stream; the distance between the two ends is the chord of the angle of skew of the bridge. The following is a table by which the angle can be determined:

Radius equals 36 in.

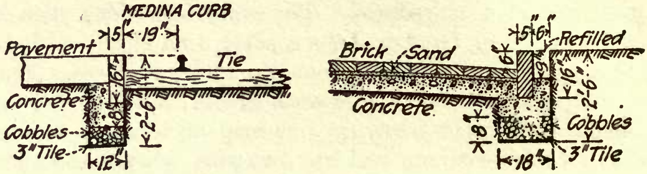
Chord	Angle	Chord	Angle
18 in.	29° 00′	36 in.	60° 00′
20 in.	32° 20′	38 in.	63° 40′
22 in.	35° 40′	40 in.	67° 20′
24 in.	39° 00′	42 in.	71° 20′
26 in.	42° 20′	44 in.	75° 20′
28 in.	45° 40′	46 in.	79° 20′
30 in.	49° 20′	48 in.	83° 40′
32 in.	52° 40′	50 in.	88° 00′
34 in.	56° 20′		

Intermediate angles can easily be interpolated.

Helps for Municipal and County Engineers

Tile Drains Under Curbs in Syracuse

The accompanying sketches show how the City of Syracuse drains all pavement foundations. The curbing is set in a block of concrete 18 in. wide and 12 in. deep. Under this block of concrete is 18 in. of cobblestone filling, along the edge of which is laid a 3-in. tile drain which empties into the sewer catch-basins. Wherever there are street railway tracks a 5 x 16-in. Medina curb or header is placed against the ends of the ties and a similar construction, as shown in the right-hand sketch, is used. It is said that in the spring, when the frost is coming out of the ground, these drains empty a continuous flow into the sewer catch-basins, and there is

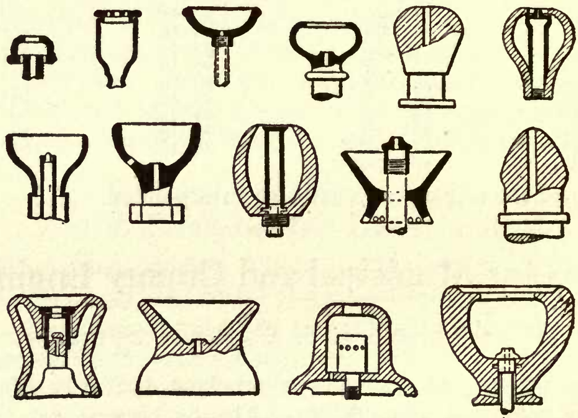


Standard Drainage Details for Concrete Curb (Left) and Special Curb at Railroad Crossing (Right)

no question but that they save many pavement troubles. They are used in all kinds of subsoil and beyond the price of the tile they add practically nothing to the cost of the pavement.

Types of Drinking Fountains Tested

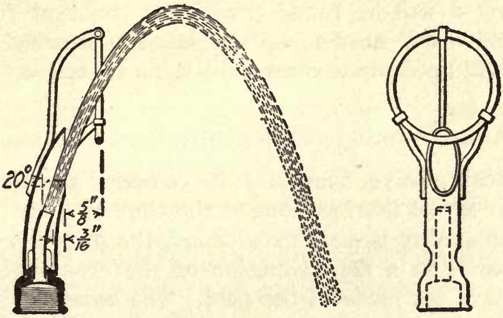
Tests of 77 drinking fountains of 15 different types showed that due to improper design all were possible sources of infection of the users. No less than 80% of the fountains and the water from 11% of them contained streptococci, although none were



These Fifteen Types Showed 80% of the Fountains and 11% of the Water Samples Infected

found in the water supplied to the 18 buildings in which the fountains were located.

The infection was due to contact between the lips of users and the structure of the fountains, or to water falling back from lips to fountains, owing to vertical discharge of the jet. To keep lips away from the fountain structure and water from falling back on it, and to prevent water from being retained in fountains with



Three Tests of This Protected Drinking Fountain Showed No Streptococci Infection

cup- or ring-shaped depressions, the fountain shown herewith was designed. Three bacterial tests showed no streptococci on either the fountain or the water discharged from it.

When To Haul, When To Waste and Borrow

A simple formula by which to calculate the economical length of haul beyond which it is preferable to waste and borrow may be developed as follows:

Take two adjacent sections, one in cut, the other in fill, and each containing the same volume of material V, measured in excavation in both cases. Under this condition the material taken from the cut will just make the fill, and therefore, provided the haul from cut to fill is of a certain length, the total cost of grading the two sections, with all the material from cut used in fill, will be the same as by the system of borrow and waste. These two conditions may be expressed by the equation

$$V(a + dx/100) = V(a + b) + Vc$$

in which a equals cost of excavating and loading, in cut, per cubic yard; b, cost of hauling and dumping wasted material, per cubic yard; c, cost of borrow and fill, not rolled, per cubic yard; d, cost of hauling and dumping material taken from cut to fill, per cubic yard hauled, and x length of haul, center of gravity of cut to center of gravity of fill, in feet.

Eliminating V and a from the equation and reducing,

$$dx/100 = b + c$$

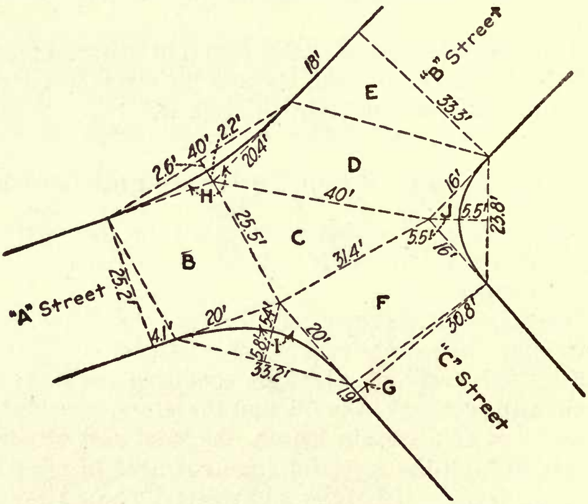
whence

$$x = 100(b + c)/d$$

Very likely d will be found practically constant for the entire job, but b and c will need to be estimated separately for each cut and fill, and will no doubt show considerable variation.

Irregular Street Intersection Area Calculations

It is almost always necessary to compute the areas of some very irregular street intersections at the time of their improvement. Unless some planning is done beforehand, the proper measurements, which will result in a determination of the area with any degree of precision, are not made in the field. The accompanying diagram of a hypothetical intersection serves to illustrate the use of a special

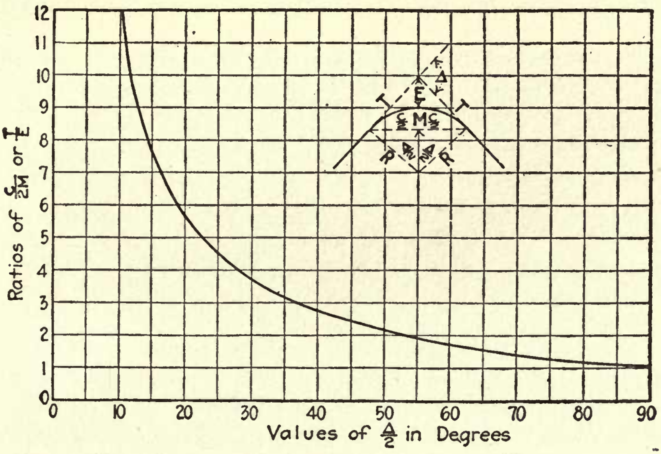


Computations of Areas of This Nature Simplified

curve by which the calculations are simplified, and its employment will make the fieldwork as simple as possible. Only a very brief explanation will make clear the proper procedure to follow in the field.

Let us assume that the areas of H, I and J are desired. While, of course, it is not exactly true that the curves at the intersection are always arcs of circles, they may be considered so for practical purposes, and very close results will be reached if proper averages are taken.

To compute these areas, the average radius and the internal angle must be determined. Since the ratio of *T* to *E* is the same



Enter This Curve with Average of Linear Measurement To Get Average Angle

as that of *C* to 2*M*, as may be seen from the small diagram given with the curve, the one curve is all that is necessary. To determine, for instance, the area marked *J*, the procedure would be as follows:

$$\frac{T}{E} = \frac{16.0}{5.5} \text{ or } 2.91$$

$$\frac{C}{2M} = \frac{23.8}{11.0} \text{ or } 2.16$$

$$5.07$$

Average 2.53 equals "Ratio."

With this ratio, using the curve, $\frac{\Delta}{2} = 43°$

$$\therefore \Delta = 86°$$

Then

$$R = \frac{16.0}{\tan 43°} = \frac{16.0}{0.933} \text{ or } 17.2$$

or

$$R = \frac{11.9}{\sin 43°} = \frac{11.9}{0.680} \text{ or } 17.5$$

$$34.7$$

Average 17.35

Area inclosed by the tangents and the radii, 17.35 × 16.0 equals 277.5

Area of segment of circle, 86/360 × π × 17.35² equals . 226.0

J 51.5 sq.ft.
5.7 sq.yd.

If the curve is considered as a parabola, the area might have been calculated in the following manner, but it does not seem at all certain that the result is as near the actual value as is obtained by the method outlined above.

$$\text{Area} = 2 \times M \times \frac{C}{4} \times \frac{2}{3}$$

$$\text{Area} = 2 \times 5.5 \times \frac{23.8}{4} \times \frac{2}{3} = 43.7 \text{ sq.ft.}$$

$$J = 4.85 \text{ sq.yd.}$$

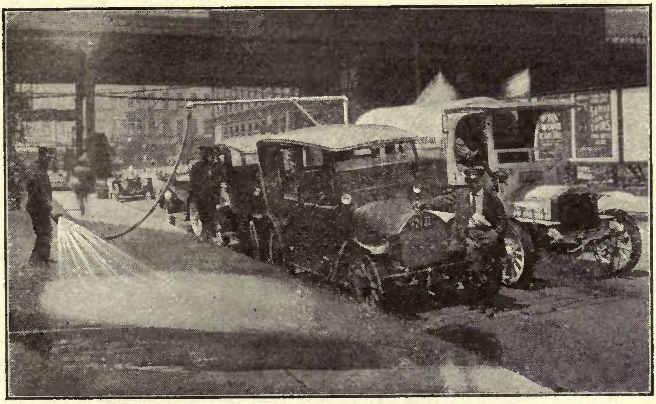
It may be seen that the first method is more likely to give a better result than the one based upon the curve being a parabola, because more measurements are utilized. However, either assumption will simplify the computation over the usual method.

Sidewalks Flushed Over Tops of Parked Automobiles

The downtown sidewalks as well as the streets in Chicago are flushed every night. To expedite the sidewalk work, there has

Extension Pipe When Not in Use Folds Over Top of Tank

recently been added to one of two tank trucks a pipe extension to clear parked automobiles. It is connected to the discharge line from the pump with a stuffing-box joint and has a knee brace of the same 2½-in. pipe as the remainder of the line. A single outfit can flush the whole 72,000 sq.yd. of area in the territory covered in an 8-hour night at a cost of 20c. per 1000 sq.yd. It is usual, however, to let the two trucks work at the job, although from the



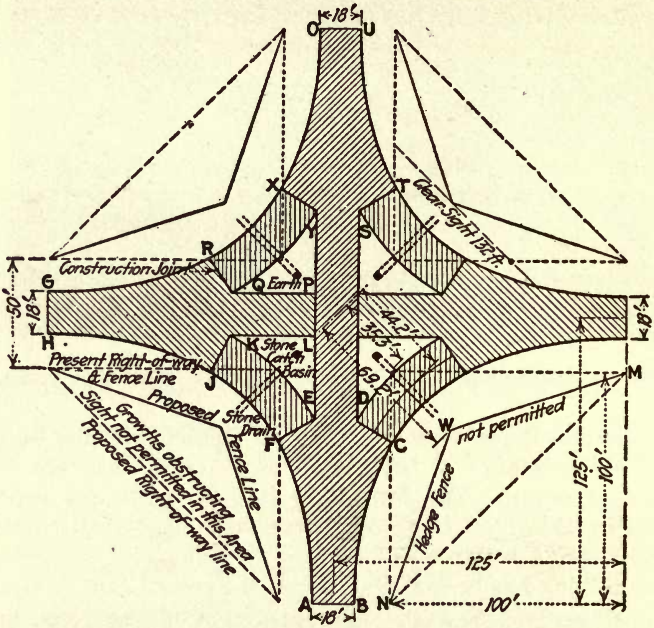
Parked Automobiles Are Not Disturbed by Sidewalk Flusher

second one the hose must be dragged behind vehicles near the curb. The remainder of the night's work is to flush the 120,000 sq.yd. of pavement. The fan nozzle is 6 in. wide and delivers a stream ½ in. thick. It is played toward the gutter and carries the dirt and surplus water ahead of it. No complaint of damage to walks or calking has been made. When the second tank is equipped, the connection will be made near the front of the tank, so that there will be no danger of bending the pipe, should the truck run it into something when half-way extended.

A Modern Intersection for Paved Roads

It is appreciated by automobile drivers that the loss of momentum and time due to slowing down to turn a 90° corner within the limits of a 50-ft. highway is about equivalent to that required to travel some 1500 ft. on a tangent of similar grade. Another difficulty with the usually designed intersection is the lack of sufficient clear-sight to enable the driver to realize the approach of a motor on an intersecting road. To overcome these difficulties, the design shown in the accompanying illustration has been put forward; and as may be seen, within the limits of the proposed highway the clear-sight is 132 ft., though in reality it would be much more than this if the regulations concerning vegetation were enforced.

While the total area of pavements in the proposed design is 1703.6 sq.yd., only 739.6 of this is necessary for the curve connection shown, the remaining 954 sq.yd. constituting 482 lin.ft. of main-line pavement, 18 ft. wide. Pavements 18 ft. wide being ample for two



Proposed Intersection Gives 136-Ft. Clear-Sight

lines of motor traffic at high speed, they need not be made still wider on curves where speed is necessarily reduced. Likewise, there would seem to be no good reason for widening 10-ft. pavements on curves; 15- or 16-ft. pavements, however, should be widened to 18 ft.

Brick and concrete pavements are generally crowned 2 in. The preservation of this crown at the intersection would prove objectionable, so it should be reduced at the intersection to about ½ in. and tapered out to the full crown in a distance of about 10 ft. in each direction.

Sections like *G, H, J, K, L, P, Q, R* should be built monolithic with the usual convexity of surface at *J, K,* although *J* is depressed.

Areas like *H, J, K* will come out warped surfaces easily built by an experienced contractor. The 10 construction joints shown should be nothing more than planes of cleavage. Sections like *K, E, F, J,* which are built last, have their corner elevations fixed by the main pavement. The usual convexity of surface is preserved, therefore, and the inner edge *F, J* is depressed to meet the required elevation.

In areas like *K, L, E* the surface of the ground should be kept about 1 in. below that of the surface of the pavement adjacent. The catchbasins and drains will keep the ground dry.

Setting Street-Corner Radius Stake

In setting radius stakes for street corners where the angle of the intersecting streets is not a right angle, the solutions shown in the following sketch save considerable time in finding the correct location for the radius stake.

Two methods may be used: (1) with transit at *E*, the intersection of the curb line and the center line of the intersecting

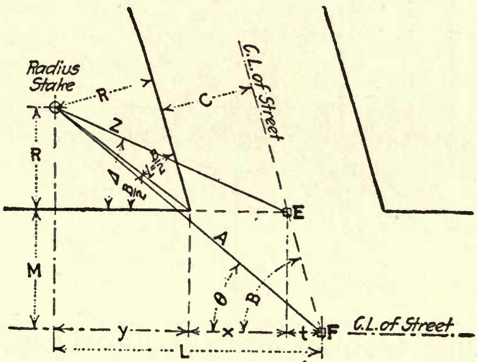


Diagram for Setting Street-Corner Radius Stake

street; (2) with transit at *F*, the intersection of the center line of the two intersecting streets. Considerable time and instrument work are saved by using the method with *F* as instrument point.

For method 1, transit at *E*, the formulas are:

$$x = \frac{C}{\sin B} \qquad y = R \cot \tfrac{1}{2} B$$

$$\tan \Delta = \frac{R}{x + y} \qquad Z = \frac{R}{\sin \Delta}$$

For method 2, transit at F, the formulas are:

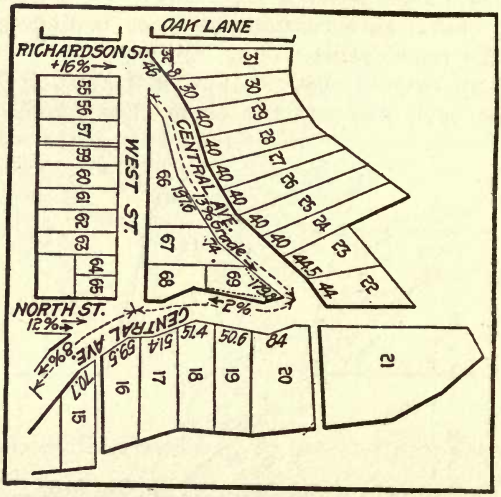
$$x = \frac{C}{\sin B} \qquad y = R \cot \tfrac{1}{2} B$$

$$t = \frac{M}{\tan B} \qquad L = x + y + t$$

$$\tan \theta = \frac{R + M}{L} \qquad A = \frac{R + M}{\sin \theta}$$

Street Assessments in a Hillside Town

It is believed that the results obtained by this method for making street improvement assessments in a hilly town with crooked streets and irregular lots are more nearly equitable than those obtained by the ordinary front-foot method.



Fitting Assessments to a Steep, Crooked Street

Arrows indicate upgrades. Heavy line shows assessment district boundary. Frontages given in feet and tenths

The following factors are taken into consideration: (1) Frontage; (2) area; (3) assessed valuation; (4) the benefit or damage to each lot by virtue of its new position with relation to the graded street; (5) correction for over-assessment, where the rates would be excessive.

The method of making the assessment is as follows: The entire cost to be assessed is distributed in amounts directly proportional to (1) the frontage, (2) the area and (3) the value as shown in Columns 5, 6 and 7 of the table. The mean of these values is then computed (Column 8). To this mean a benefit or damage factor is applied varying with the relative position of the lot with reference to the street surface before and after grading. The figure obtained in Column 8 in the case of lots in Class 1 (considerably damaged by grading) are multiplied by $\frac{2}{3}$; lots of Class 2 (slightly damaged), by $\frac{5}{6}$; lots of Class 3 (neither benefited nor damaged), by 1; lots of Class 4 (slightly benefited), by $\frac{7}{6}$; and lots of Class 5 (considerably benefited), by $\frac{4}{3}$. The results after this operation are shown in Column 10. A wider and more refined variation could be applied in cases where the conditions warrant it. The sum of the quantities in Colmun 10 is seldom equal to the total cost to be assessed, so that the difference between the sum of Column 10 and the desired total is distributed in proportion to the values found in Column 10 (added in the case of the example). The corrected quantities are given in Column 11. An inspection of Column 11 shows that Lots 66, 68 and 69 are assessed an amount in excess of 50% of the tax assessor's valuation—a percentage which has often been held to be a confiscatory rate. These amounts are then reduced to a sum slightly below 50% of the value, and the excess is then distributed at a uniform rate over the remaining lots, giving the final values shown in Column 12.

The example given is for the improvement of Central Ave. shown on the diagram (Fig. 1).

METHOD OF COMPUTING STREET IMPROVEMENTS ACCORDING TO FRONTAGE, AREA AND VALUE, WITH BENEFIT FACTOR ADJUSTMENT

Lot (1)	Frontage, Ft. (2)	Area, Sq.Ft. (3)	Value (4)	Cost Distributed According to— Frontage (5)	Area (6)	Value (7)
16	59.5	6,900	$1000	$152.26	$177.94	$211.05
20	84.0	12,000	800	214.96	309.45	168.84
21	0.0	23,500	1000	0.00	606.01	211.05
66	197.6	7,100	400	505.66	183.08	84.42
68	80.0	4,000	300	204.72	103.15	63.32
69	179.8	3,300	300	460.10	85.10	63.32

Lot (1)	Mean of Cols. 5, 6, 7 (8)	Class of Benefit (9)	Col. 8 with Benefit Factor (10)	Col. 10 Adjusted (11)	Final Cost Distribution (12)
16	$180.42	1	$120.28	$126.37	$136.08
20	231.08	3	231.08	242.33	260.95
21	272.35	4	317.73	332.97	358.20
66	257.72	3	257.72	270.17	199.00
68	123.73	5	164.96	172.94	149.00
69	202.84	2	169.05	177.44	149.00

Home-Made Portable-Pump for Manholes

A portable centrifugal-pump outfit to unwater manholes has recently been put together in the shops of the Lincoln Park Commission, Chicago, for use in draining the electrical underground distribution system. The equipment is mounted on low wheels and can be hauled by an automobile or a truck. The 12-hp. 1500-r.p.m. marine-type gasoline engine is direct-connected to a centrifugal pump rated at 500 gal. per min. at 2000 r.p.m. Accessories to the pump and engine are a 23-gal. gasoline tank, 5-gal. automobile radiator, a 20-gal. circulating-system tank and a 66-gal. primary tank. With the available speed, 4-in. intake and 3-in. discharge hose, 300 gal. per min. can be pumped against a 15-ft. head, including suction and discharge, but water may be lifted 30 feet.

Control of the entire outfit, including the spark and gasoline levers, the outlet and air-vent valves and the valves on the circulating system, are all grouped at the front end of the machine within easy reach of one man.

Means have been provided for obtaining easy access to any part by making the inclosing walls either hinged or entirely removable. The pump has proved its value in pumping dry a line of ten 3-in. ducts that lie along the shore of Lake Michigan and are arranged to drain from one manhole to another.

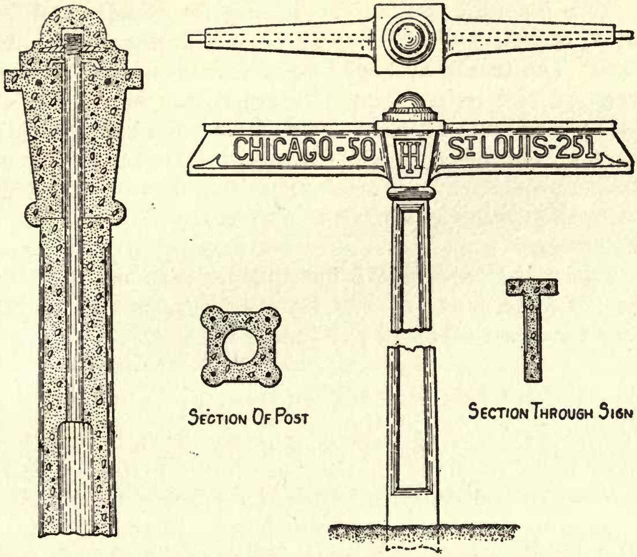
A detailed statement of the cost of constructing this outfit in the shops of the commission is given in the accompanying table.

COST OF BUILDING EMERGENCY WATER PUMP

Material	
1 marine engine and muffler	$90.00
1 radiator	25.00
To build truck for engine pump and wheels	225.30
To install engine on pump truck	69.07
Painting pump truck	21.54
To supplying suction hose, valve and fittings	125.89
Three 1¼-ft. valves	2.82
1 cap	.10
12 bolts, various sizes	.12
5 pipe plugs, various sizes	.36
5 bushings, various sizes	.45
12-ft. water pipe, various sizes	2.34
28 nipples, various sizes	2.24
4 tees, various sizes	.30
6 unions, various sizes	.99
56 screws and nuts, various sizes	1.00
19 ells, various sizes	1.61
6 padlocks, various sizes	6.60
Miscellaneous material	24.13
Total	$599.86
Labor	
Mechanic, 31 hours at 50c.	$15.50
Helper, 104 hours at 32c.	33.28
Total	$48.78
Garage expense (overhead)	120.85
Grand total	$769.49

All-Concrete Road Sign

Competition for the official state-aid road sign for Illinois, which the State Highway Department announced last June, brought designs from about 75 competitors throughout the United States, from California to Massachusetts. It was stipulated that the drawings should illustrate the proposed type of sign to be erected along all state-aid roads.



This Is the Design Which Won the Prize Competition for Illinois Road Signs

The accompanying illustration shows the successful design. It was selected because of its simplicity and durability, and its evident ability to serve the purpose to which it will be put. The sign is of concrete construction.

Garbage Collection by Motor Truck

The City of Los Angeles collects its garbage without cost to the residents, the department being maintained by general taxation. Garbage is delivered under contract to a corporation organized to operate a disposal plant for handling garbage and other refuse produced by the city. The contract stipulates that the company pay the city 51c. per ton delivered for all garbage.

The city is divided into two zones, in one of which garbage is collected by teams and in the other by motor trucks. For the latter the full-load haul ranges from six to nine miles, averaging approximately eight miles. In this zone a total of about 300 tons of garbage is collected each month by two 2½-ton motor trucks at a cost of $2.76 per ton. Noncombustibles in both districts are collected by seven 2½-ton trucks that bring in a total of about 3300 cu.yd. of rubbish per month at a cost of 94c. per cubic yard.

The cost of operating the trucks ranges from $210 to $250 per month. This includes fuel, driver, lubricants, repairs and depreciation, but is exclusive of the two garbage collectors who accompany each truck. The trucks average two or more loads per day and haul an average of 2¾ tons per load. Before trucks were adopted, these collections were made by three-horse teams, each of which made a single round trip each day. The use of motor trucks for the outlying districts has proved so satisfactory that the city would not consider a return to the use of teams for this zone.

The short-haul zone is served by teams using both day and night shifts. The night shift has a monthly average of 2800 tons at a cost of about $1.18 per ton. The day shift averages about 2200 tons per month at a cost of $2.15 per ton.

Home District for Industrial Workers

A ninety-acre tract of land on the southern boundary line of the City of San Francisco has been purchased and is being laid out and improved as a district in which the average industrial worker will be able to purchase his own home. Building lots in the residential district are far beyond the reach of the average mechanic; and as a result the steadiest and best class of workmen have been locating in cities across the bay. This action has tended to attract industries to those cities and away from San Francisco.

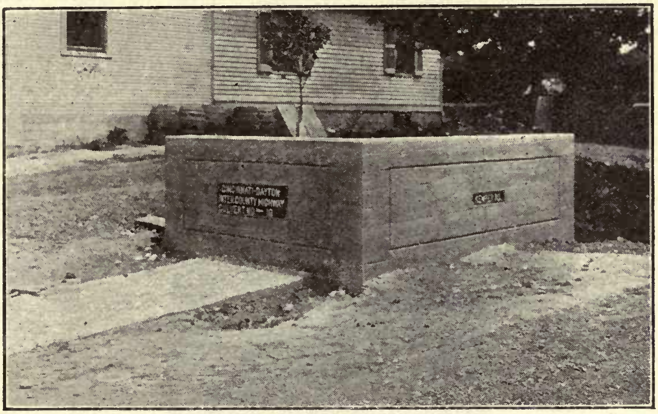
The project contemplates the construction of a large number of small houses which will be sold on such terms that the monthly installments will amount to about the same as the rental such families usually pay, the total cost to be about $2500 or $3000. The improvement of the entire tract at once and the favorable location of lines of transportation, schools, retail-market centers, etc., make it possible to offer the industrial worker a proposition that is expected to have a notable effect on the San Francisco labor problem.

The single houses are to be, in general, of the bungalow type, containing four rooms and bath and all modern conveniences. The prices fixed on 50 x 100-ft. lots average less than $500. Other quarters for unmarried men are contemplated, and it is expected that the plan will be based on somewhat the same idea as the "community houses" in England's industrial districts.

The plans contemplate the ultimate accommodation of 15,000 people in this district, which is not far from the new Southern Pacific shops, where about 5000 men are employed. The site is also near the large dry dock under construction at Hunters Point and is within easy reach of what is known as the industrial section of the city.

Every Culvert is Numbered

Hamilton County, Ohio, of which Cincinnati is the county seat, places a cast-iron sign with the name of the highway and the number of the culvert on the parapet and wing-walls of every culvert.



Number of Culvert and Name of Road Help Officials and Tourists

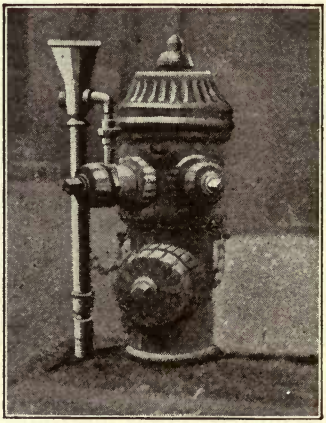
The accompanying illustration shows a culvert at the intersection of two roads, the Cincinnati-Dayton intercounty highway and the road at right angles, Kemper Road. These signs are a great convenience to tourists and also assist the office record system.

Street Signs Show House Numbers

It is sometimes hard, even to one who is acquainted with a city's streets, to tell from the corner signs just how near he is to the particular house number he is seeking. If the seeker is in a street car, the situation is aggravated. Particularly is this so in cities where the house numbers bear no relation to the distance of the cross-streets from a meridian street. The new style of street sign adopted by Cincinnati, Ohio, avoids this difficulty. All streets having car lines are now supplied with the new signs, which show on a separate panel the numbers of the corner houses. This is an admirable advance over the design used for the more important street signs of New York City, which show the crossing street in smaller-size lettering above the indicated street.

Drinking Fountain Attached to Hydrant

A street drinking fountain supplied from the hose connection of a fire hydrant at Galion, Ohio, is shown by the accompanying view, in which the small vertical pipe at the left supports the fountain and serves as a waste connection to the sewer. The supply line is tapped into a nipple screwed into one of the two hose outlets. This arrangement necessitates the main valve of the hydrant being kept partially open—enough at least, to bleed sufficient water for the

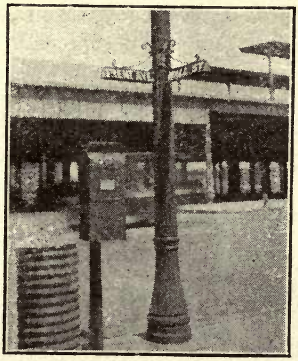


Drinking Fountain on Fire Hydrant

fountain. A self-draining hydrant, unless accurately adjusted, might waste considerable water if adopted to this scheme, and in any case a valve, too far opened, would have to be closed before steamer connections could be made to the hydrant.

Spokane Installs Low-Cost Street Signs

Simple, legible, low-cost street signs are being installed in Spokane, Wash., as shown by the accompanying illustration. Each sign consists of two enameled porcelain plates secured to a creosoted wood base and held by a bracket, clamped to a lamp post. The wood base is so shaped as to make each nameplate rest at a slight angle with the vertical, so the street light from above casts no shadow on the nameplate. Each of the four plates attached to one

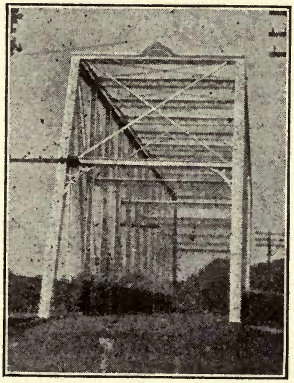


Spokane Using Street Signs Like This

lamp post costs $0.35, and the two brackets together cost $1.15, making a total cost of $2.55 for plates and brackets at a given corner. The cost of the wood and of erection is small.

White Bridges Can Be Seen at Night

The practice of painting highway bridges white so as to increase their visibility and thereby decrease possible accidents, is growing



White Bridge Is Readily Seen

People who cross this bridge at night who are accustomed to black or red bridges are struck with the ease with which the outlines of the bridge are noted. In Putnam County, Ohio, several truss bridges have been painted as shown in the view. The end posts of truss and railing are white for their full length but the inner railings and posts up to a height of 4 ft. are painted black as a protection against discoloration.

Present-Day Water-Works Construction, Maintenance, Operation and Repairs

Dynamiting a Deep Well

A water well near Kennett Square, Penn., was "shot" a short short time ago to increase the flow. It was 600 ft. deep, started at the top of a hill of elevation 460 ft. After drilling through 84 ft. of stiff clay and hardpan, solid rock was encountered with successive strata as follows:

	Ft.		Ft.
Sand rock	121.0	Gray granite with green serpentine seams	2.0
Flint rock	90.0	Gray granite	40.0
Blue granite	17.5	Blue granite	3.0
White quartz	1.2	Gray granite	72.0
Gray granite	47.8	Bastard granite	84.0
Blue granite	17.5		
Gray granite with quartz seams	10.0		
Blue granite broken	10.0	Total	516.0

An 8-in. steel casing was sunk to rock and grouted to exclude surface drainage; the hole through the rock was 6 in. At 600 ft. the flow was measured and found to be only 3⅓ gal. per min. To go deeper would mean expensive pumping equipment. It was thought that a discharge of nitroglycerin would shatter some of the water-bearing strata.

Indications were that the stream supplying the well was about 320 ft. below ground level. Just below this point the well was bridged by means of a ball of stiff wire forced to the desired depth. Concrete was placed upon this. A special type of solidified nitroglycerin—which is commonly used for shooting oil wells—formed the charge, which consisted of 190 qt. The explosive was packed in 10 tubes, 5¾ in. in diameter and 7 ft. long. These were placed in the well one above another, and the whole was discharged by dropping a jack squib down the well.

A column of water 500 ft. high was blown from the well, following which the latter was tested. The test pump working continuously for 7 hr. pumped 10,000 gal., which was at the rate of 22 gal. per min.

An Aid to Reservoir-Storage Studies

In studies of natural or artificial reservoirs for storage purposes. it frequently is necessary to determine the rise or fall in the surface level, due to certain rates of outflow and inflow. If the outflow is not constant for the varying levels, the required rise or fall due to a given inflow is ordinarily arrived at by a laborious trial method until a balance is reached between the various factors. For illustration of the method herein described, let a reservoir of 100 sq.mi. be assumed, with a discharge curve as shown by the heavy line in the figure. The theoretical rate of inflow—including rainfall

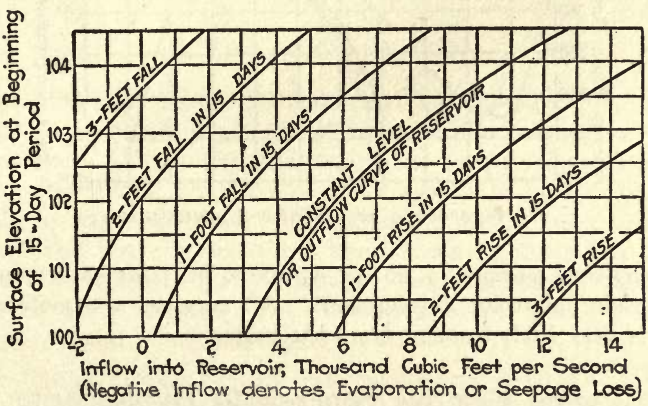
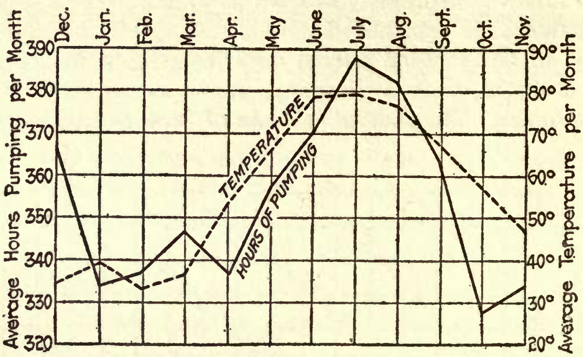


Chart for Determining Change in Surface Level of Reservoir

on, and evaporation and seepage from the reservoir—is equal to the average rate of outflow from the reservoir plus or minus the rate produced by the rise or fall in the surface level over the given period. By assuming several initial levels within the limit of probable requirements, and several rates of rise and fall during a period of 15 days, the corresponding inflow is determined, upon which the remaining curves in the figure are based. In using such a chart the above process is merely reversed. Given any inflow, and a certain reservoir level at the beginning of the period, the rise or fall during the period may be directly taken off. For a level of 102 and an inflow of 10,000 sec.-ft., the reservoir will rise 1.25 ft. during the half month. The chart may be constructed for any shape of outflow curve, and for any period of time, and where there are a considerable number of computations to be made it will prove a time-saver.

Temperature and Water Consumption

The accompanying curves show a notable similarity between the number of hours of pumping per month and the average temperature per month for a suburban water plant in Maryland. The plant has



Temperature and Water Consumption

five deep-well pumps, 7½ mi. of 4- and 6-in. main, and supplies a high-grade suburban development. All services are metered, and there is very little leakage from the mains.

Liquid Chlorine Superior to Hypochlorite

Liquid chlorine cost much less and effected more bacterial reduction than hypochlorite and was in other respects more satisfactory on an Illinois installation. With hypochlorite at 7c. and liquid chlorine at 20c. the average cost of hypochlorite treatment for January was $1.07, compared with only $0.28 per 1,000,000 gal. for liquid chlorine.

The average reduction in bacteria count of daily plates made on nutrient agar incubated at 37° C. for 24 hours, was as follows: In January when hypochlorite was used the average raw-water count was 6300 and the filtered-water count was 15. In June, when liquid chlorine was used, the average raw-water count was 7980 and the filtered-water count was 11. In B. Coli tests, the raw water shows 100% for each month, while the filtered water shows 1.6% in January and 0.0% in June. These results were obtained by means of 1 c.c. samples in all cases. Also note that while hypochlorite was used 0.46 p.p.m. of available chlorine was applied and while using liquid chlorine 0.22 p.p.m. of chlorine was applied.

Deep Wells Cost 0.82 Cent per 1000 Gallons To Operate

Costs of maintaining and operating for 16 months five deep wells supplying the University of Illinois were equivalent to an average of $151 per year, or 0.82c. per 1000 gal. The following data were given at the recent meeting of the Illinois section of the American Water-Works Association:

Well	First Cost: Well Casing and Screen	First Cost: Motor and and Pump	Operating Cost: Labor	Operating Cost: Material	Capacity of Pump Gal. per Min.	Percentage of Day Pump Was in Operation
A	$559	$375	$172.07	$100.26	60	44
B	546	813	56.51	2.26	69	34
C	699	788	202.73	82.86	81	70
D	1348	758	113.05	42.93	71	86
E	891	810	147.26	88.08	75	89

The wells have been drilled about 140 ft. deep into glacial drift, and the water stands about 110 ft. below the surface when pumping is in progress. The pumps had been in use for periods ranging from one to eleven years; hence the results are believed to represent fairly well the average performance of the pumps during their useful life.

The chief cause of trouble is the fine sand getting into the well and into the pump. Rods, couplings, working barrel and packing are worn quite rapidly. The conditions under which the pumps work are thought decidedly poor.

Paper Replaces Hemp for Pipe Joints

Pipe-joint materials became so scarce on account of the war demands that a paper packing for joints of cast-iron and steel pipes has been tried in Zurich, Switzerland.

The packing is made of rolls of newspaper, conical in form, 6 in. long, $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in diameter, nested together and pasted. They are waterproofed by impregnating with tar oil. They are flexible and compressible and can be driven very tight with a calking iron. A $\frac{3}{4}$-in. lead joint is poured over the paper, but even without this such joints held a pressure of 750 lb. per sq.in. after 14 days in water.

Filter Wash Water Pumped by Compressed Air

Having on hand two sheet-steel tanks of 29,000-gal. capacity and an air compressor with plenty of off-peak time, the designers of the Lawrenceville, Ill., filter plant were enabled to eliminate the purchase of a wash-water pump, the compressor being available to store up sufficient air under pressure.

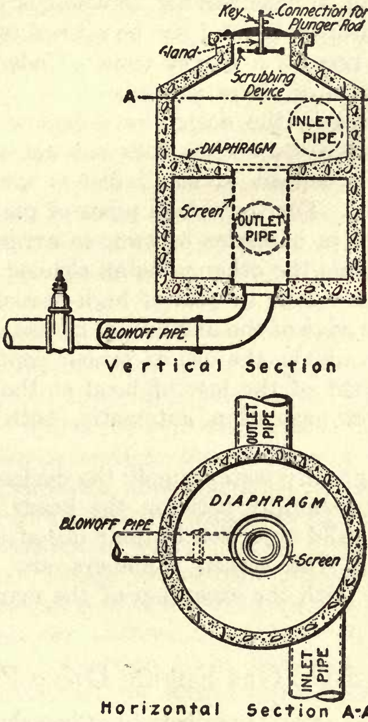
The plant consists of two rapid filters of 180 sq.ft. filtering area each, with the usual system of strainers fitted for washing at a rate of 2 ft. vertical rise per minute. The two tanks formerly used on the distribution system as storage tanks and pressure equalizers, were available for air storage.

In washing a filter the procedure is as follows: Starting with the tanks three-fourths full of water, air is pumped in through a 2-in. line until a pressure of 25 lb. per sq.in. has been attained. The air line is then shut off adjacent to the tanks, and the compressor fills an air-storage reservoir of 340 cu.ft. of free air to a pressure of 80 lb. per sq.in. This storage is on the air line leading to the wash-water tanks. When the required pressure is attained and the storage opened into the line, the filter wash is started. By proper manipulation of the wash-water valve an even wash can be maintained at the required rate. When the filter has been washed, the air pressure is released and the tanks refilled from city service. The only objection reported to the procedure is that the operator may be careless and not give proper attention to the manipulation of the wash-water valve, in which event it is possible to blow up the sand bed.

New Design of Screen Chamber

The customary method of removing grass, leaves, sticks, bits of bark and fish from reservoir and lake water supplies is to install either a screen affixed to the pipe or else two screens in series, one of which may be drawn up out of the water for cleaning while the other is in service. The former arangement, which is applicable only to very small depths of water on the screen, is economy itself in first cost, but its use has not always proved so economical; as owing to any one of many causes the screen might not receive the necessary attention at the very time when it was most needed. The latter necessitates a considerable structure to hold the screens in place and house them while being cleaned, besides the trouble and expense of cleaning.

To obviate these and other difficulties the pressure screen chamber here described was designed. It consists essentially (see illustrations) of a vertical cylinder divided by a horizontal diaphragm into two compartments; the upper, or inlet, compartment has communication with the lower, or outlet, through a circular opening in the diaphragm and thence through the meshes of an open-ended cylindrical screen resting in the lower compartment, of a diameter nearly that of the opening. The lower end of the screen is concentric with the end of a blowoff pipe with a gate valve on it, normally closed. The inlet pipe enters the inlet compartment tangentially, while the outlet may leave in any direction relative to that of the inlet, preferably in a radial position. Any flow from the inlet pipe sets up a whirling motion in the water in the upper compartment. In passing through the screen cylinder it has a circumferential as well as a downward motion, which, owing to the



Reinforced-Concrete Pressure Screen Chamber

passage of water through the meshes of the screen, diminishes as the bottom of the screen is approached. The result of this is to confine, largely, the foreign matter carried by the water to a central cone the base and height of which are approximately those of the screen. The upturned end of the blowoff pipe being made of nearly as great a diameter as the screen, this results in an accumulation of débris directly in the pipe. When blocking of the screen has progressed to a point at which there is a noticeable loss of head at the screen—as measured preferably by a mercury

U-tube or a differential gage—the blowoff gate is opened; the head in the blowoff pipe is then reduced to zero, or nearly so, the hydraulic gradient from reservoir to screen chamber is increased, and the high velocity established is transmitted directly to the water passing diagonally downward over the face of the screen and out the blowoff pipe. Ordinarily, the cleaning of the screen is accomplished in about the time that it takes to open and close the blowoff gate. If it is desired to maintain a considerable continuous flow through the outlet pipe, the blowoff gate need not be opened wide, in which case the operation will require a longer time. Under no conditions is an appreciable amount of water wasted.

Also incorporated in the design is a hollow segmental brush, for use in cases when the screen does not get attention for such long periods that a deposit of small fish is not readily removed by the flowing water. For the intake pipes of pumping stations the devices are best set in batteries of two, so arranged that one can be put in service while the other is being cleaned. In this case the cleaning is preferably done by jets of high-pressure water directed downward from the edge of the diaphragm across the screen. Where electric power is available, the use of proper contact devices at the point of measurement of the loss of head at the screen will make the entire screening operation automatic, both for gravity and pumping supplies.

For use with a gravity water-supply the devices have been found to operate most successfully between the heads of 40 and 60 ft., though there is no valid objection to their use at other heads, under certain conditions. The screen chambers are made entirely of reinforced concrete with the exception of the manhole cover, which is of cast iron.

Geared-Up Gas Engine Drive Pumps

Formerly, water was supplied in Clarksburg, W. Va., by engine-driven centrifugal low-service pumps and duplex direct-acting high-service pumps, both taking steam from gas-fired boilers. When additional capacity was required it was decided to use pumps driven by gas engines in view of the rapid depletion of the natural-gas supply of the district and the necessity of making the city's fuel wells last as long as possible. The preliminary estimates showed that the gas-engine units would demand only about a third of the fuel needed for the boilers and steam machines.

The equipment secured after bidding comprised a 4,000,000-gal. centrifugal pump, for 35-ft. head, driven by a 50-hp. engine, and a 4,000,000-gal. pump, for 350-ft. head, driven by a 350-hp. engine.

The small unit supplies the filter beds, and the larger ones pumps into the city reservoir. The engine speed is stepped up by double helical gears from 200 r.p.m. to 1385.

During a 10-day continuous run the total gas consumption of both units averaged 82,200 cu.ft. of gas per day; the delivery was held up to 4,100,000 gal. per day against 330- and 30-ft. heads, giving a load of 258.5 water horsepower. The gas comes from the city's wells and is charged up at 6c. per 1000 cu.ft., although the local commercial power rate is 8c. At 6c. the fuel costs $6.96 per hp. per year, or 0.079c. per hp.-hr.

The complete cost of pumping equipment is reported to have been approximately $17,500; the substructures, superstructure, crane, piping and appurtenances cost complete $13,905, bringing the total to $31,405. The interest, depreciation and upkeep, figured at 10% (equivalent to 12% on machinery and 8% on structures), would be $3140, or $12.18 per hp.-year, or 0.138c. per hp.-hr. 0.217c. per hp.-hr., exclusive of labor and supplies.

Electric Tunnel Lights in Closed Box for Safety

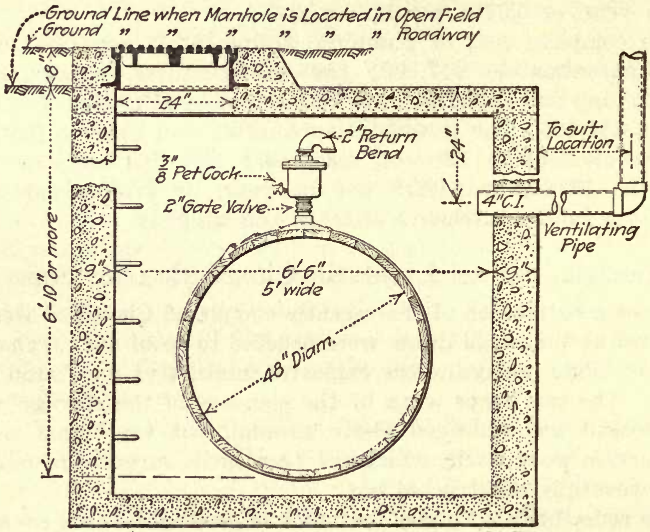
In the construction of the recently completed Cleveland west-side water-works tunnel all lights were ordered to be of such a character that they could not ignite the explosive mixture of gas found in the tunnel. The cap lamps worn by the men are of the storage-battery type, locked and unlocked above ground, but the lights used in construction work itself, which are necessarily larger, are built into a very carefully constructed box.

The reflectors are "bullet" automobile headlights, each containing a 24-watt lamp that is protected by wire-glass and connected to a 90 ampere-hour storage battery set midway of the length of the box. The latter is 13 in. wide, 10 in. high and 23 in. long, outside dimensions, and is lighted and locked above ground—the key being kept there. The carpentry work on the boxes is of a very high grade, all joints being tight, serving to keep the explosive gas out of the box as much as possible, in the event of a spark being caused by a loose connection at the battery.

Air Valves in Large Vented Vaults

Air valves on the newer wood-stave pipe lines bringing water to Denver, Colo., from the mountain sources are placed in large concrete manholes. Formerly, it was the practice to use open manhole covers, but they have been discontinued in favor of ventilating pipes. The manholes could not always be depended upon, for earth and, in winter, snow and ice might fill the openings.

For a 2-in. automatic air valve, of which 100 are in use, set on the newer lines one at each summit, 4-in. ventilating pipes are used extended 8 to 10 ft. above the surface. If the supply pipe happens to be laid in a roadway, the ventilating pipe is led off to the side or even inside the fence line to protect it from injury. Small holes, aggregating in area many times the area of the air valve, are bored near the top of the pipe, which is plugged or capped.



No Collapses with This Design

The air valve is placed on top of the pipe with a return bend on the outlet, so that any water that may be delivered during the periodical test will not drown out the operator. To facilitate testing, the gate valve is set just above the special casting through which the connection to the wood pipe is made. Also, a hole is drilled in the lower part of the air-valve body for a pet-cock. On opening the pet-cock the float will fall, if held up by air or if it happens to be stuck. If water is holding the float up, the operation of closing the gate valve and opening the pet-cock will make the float work.

Where these air valves have been installed and an absolutely sure source of air, such as here provided, is assured, no collapses have occurred and the pipes are kept running full, the air being removed as fast as it collects.

Cast-Iron Pipe Connection for Wood-Stave Pipe

The connection of a wood-stave pipe with a concrete structure is a troublesome detail. Quite often the end of the pipe is inserted into a socket left in the concrete. Subsequently the ring left around the pipe is grouted. While this method is still in use it has been the cause of some failures in wooden siphons in Wyoming, for the repair cannot be made easily when it becomes necessary to replace the staves.

One engineer handles the problem by embedding a cast-iron pipe in the concrete and then fitting the wood pipe over it. To make a water-tight joint and one that permits expansion and contraction, the cast-iron pipe is wrapped with tar-soaked oakum for a distance of 4 ft. Beginning at a point 15 ft. from the end of the pipe, the internal diameter of the wood pipe is increased by tapered staves to fit the outside of the wrapped pipe.

Pool Floor Forms Are Slotted for Water Stops

Forms slotted to hold the water stops between adjoining floor blocks were required in laying the floor of a large pool which forms one of the architectural adornments of the Kensico dam of the New York City water supply. This pool, which is 720 ft. long and 135 ft. wide, is partly in cut and partly on a rolled earth fill. It is surrounded by a wall 5 ft. thick, surmounted by cut-stone curbing, and its 8-in. concrete floor is laid on porous material with vitrified pipe underdrains. It was essential to make this floor as near watertight as possible. The floor was laid off in 9-ft. squares with a joint and water stop between adjacent squares.

Forms for the floor slabs were made in the carpenter shop from 6 x 8-in. timbers. A longitudinal groove cut along one side of each of these timbers midway between the top and bottom provided a setting for the steel water-stop strip to be embedded in each block. Each of these form pieces was made separate, and a number of different lengths ranging from a little less than 9 ft. to about 9 ft. 11 in. were turned out, as the progress of the work required the form strips to be used sometimes between blocks already cast and sometimes to overlap adjacent blocks. Forms were first set for alternate blocks in each direction, and when these blocks were concreted and the forms removed this left water-stop strips embedded in the first blocks on both sides of the intermediate blocks in each direction. These could then be filled in, leaving holes in alternate rows in each direction on all sides of which the water-stop strip would be sticking out.

As used for the first blocks, the four sides of a form were clamped in place by clips with set screws just outside the forms at the corners. These screws gripped the water-stop strips, which were laid in long lengths, gridiron fashion, over the foundation before the first of the forms were set. The forms were wedged together by driving steel or wood wedges between the clips outside of the forms. Altogether about 350 form pieces were made, and as a rule about thirty blocks were formed with them at one time. The same pieces were used continuously throughout the work, and most of them lasted the job in good shape.

Steam Jet Clears Coagulant Line

Steam jets replace water injectors occasionally on the coagulant lines at the filtration plant in Evanston, Ill. As designed, the coagulant, after passing the orifice boxes, is forced by water ejectors 450 ft. through a 2-in. lead pipe to the point of application. Considerable trouble from the alum line clogging was experienced, until a steam connection was made. After using steam for 15 or 20 min., coagulant is forced through the pipe with water in the usual manner. This cools the inside of the pipe rapidly, causing the scale to break away. Prior to this practice it was necessary to clean the steam line once a week. Once in two months is the interval of time since using the steam jet.

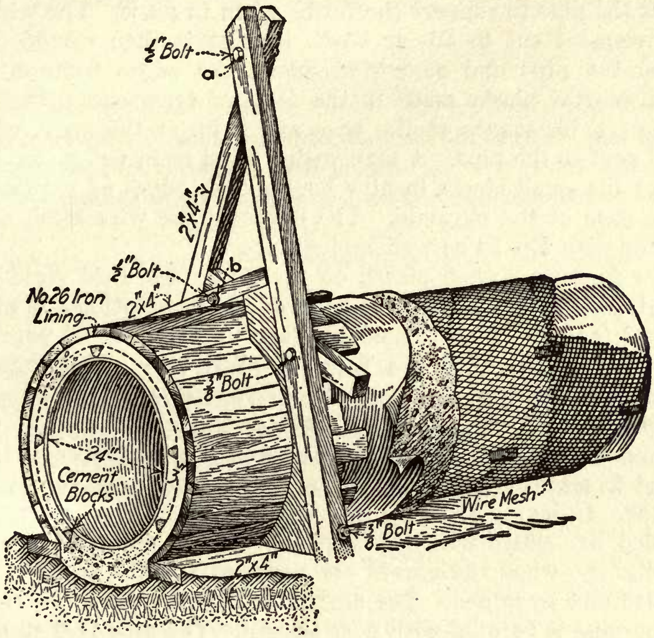
Calcium Oxide Determined by Sugar Solution

The following is the method in use in the laboratory of the St. Louis Water Department for the determinations of the water-soluble calcium oxide in quick lime. Approximately 7 grams of lime, contained in a weighing bottle, are dumped into a liter flask containing 500 c.c. of a sugar solution (160 grams per liter). Caking is prevented by causing a whirling of the solution while the sample is being added. The flask is then put on a Camp shaking machine and shaken for 30 minutes. It is then made up to the 1000 c.c. mark with carbon-dioxide-free distilled water, shaken by hand and allowed to stand overnight. Twenty cubic centimeters of this solution are then titrated with tenth-normal hydrochloric acid, using phenolphthalein as the indicator, and the per cent of lime determined. The addition of acid is continued until the first disappearance of the pink color. The color reappears in a short time, but the first disappearance is taken as the end point.

Steel Pipe Line Covered with Concrete

Old riveted-steel water pipe have been successfully incased in reinforced concrete, and in the light of the present high price of steel plates the work may be of interest to others having pipe lines to replace.

These details were worked out more particularly for use in covering 10,000 ft. of 24-in. riveted-steel pipe line used as inverted siphons working up to 80 ft. head. This line was laid 30 years ago



Old Steel Inside Form for New Concrete Pipe

and is beginning to give way near the ends of the siphons where light weight steel was used on account of low heads. Possibly 95% of the iron is still in the pipe, but it has rusted badly and pitted particularly at the seams, so that it has been necessary to make repairs during the irrigation season. The system not only protects the outside of the pipe and prolongs its life by the jacket of reinforced concrete, but eventually utilizes all the iron in the old pipe, and when it has disappeared leaves a reinforced-concrete pipe without joints, sufficiently strong to carry the pressure.

The forms are constructed of Oregon pine and lined with 26 gage black iron, which saves not only the forms but much material, making a smooth outside surface to the finished pipe. Forms for 24-in. and larger pipe are made in 8-ft. lengths, while the smaller sizes are made up in 12-ft. lengths.

After the steel pipe is uncovered it is thoroughly scraped and cleaned with steel brushes. The ground under the pipe is then shaped to the required depth, the pipe being supported on wood blocks until the forms are set. Bedplates of 2 x 4s are then spaced with a template, similar to the end section of the form, on each side of the pipe to support the forms when in place. The wire-mesh reinforcement cut to 50- or 75-ft. lengths is then wound spirally around the pipe and supported where the edges unite by small cement-mortar blocks made in the form of truncated pyramids, 1½ in. high, 2 in. square at the base and ¾ in. at the apex, which is placed next to the pipe. A man with a hand mold will make 2500 or 3000 of the small blocks in nine hours. The edges of the mesh rest on the base of the pyramid. The edges of the wire mesh are tied together with No. 24 soft stovepipe wire.

The forms are then placed on the 2 x 4s and held rigid by the two ½-in. bolts as shown. The wood blocks supporting the pipe are removed, and the pipe is held in place by a strand of wire and a turnbuckle clamp until the form is filled to a point where the concrete will support the pipe. The concrete is a 1: 2½: 1 mixture of cement, sand and crushed rock or screened gravel of ¾-in. maximum size. It is mixed by hand and poured rather wet, being worked to place with a light rod and by tapping the forms with a hammer. In laying the pipe up hill the top openings, as the forms are filled, are closed with covers clamped to place until the concrete sets slightly, when the covers are removed and the surface is well troweled and smoothed. The next morning the forms are removed, and the pipe is painted with neat cement. The pipe is then covered with soil and kept wet for two weeks.

Twelve men will easily build and backfill 140 ft. of 18-in. pipe, 100 ft. of 24-in. or 80 ft. of 30-in. pipe in a day of nine hours. The company is replacing 30-in. steel pipe under 40-ft. head, placed on bridges, with concrete siphons of the same size.

Friction Loss in Water Pipes and Fittings

The method of test upon which exponential formulas for the friction loss of head of water flowing through standard pipes and fittings were based, was to let water run from one tank to another, with and without the given pipes and fittings in the connecting line.

The velocity was computed after calibrating the free area of the pipe, weighing the water flowing in a given interval, and measuring the difference of level by hook gages. In this way the head-velocity relations were established for various velocities in pipes of ½ to 3 in. nominal size. After plotting these relations on double logarithmic cross-section paper the loss per foot of pipe could be secured. Then a logarithimic plot was made of values of K in the equation

$$h = kv^n$$

for the several sizes of pipe. From these the final formula was deduced as

$$h = 0.00685\frac{v^{1.75}}{d^{1.275}}$$

for water at 68° F. and for velocities of up to 3 ft. per sec., in ½- to 3-in. black butt-welded steel pipe.

Similar studies of galvanized pipes gave the formula

$$h = 0.00845\frac{v^{1.84}}{d^{1.75}}$$

In general, the exponent of v increases with the interior roughness of the pipe.

Increasing the temperature of the water decreased friction-head loss, apparently by changing the coefficient of v of the exponent. The hot-water experiments were not completed.

For the friction loss of flow at 68° F. through one standard short-radius steam elbow the formula deduced is

$$h = 0.0141\frac{v^{1.96}}{d^{0.26}}$$

Water-Sample Shipping Case

A shipping case holding eight 4-oz. water-sample bottles and having an ice capacity to maintain a temperature of 10° C. for 48 hours is made of 20-gage galvanized iron, 8 in. wide, 15 in. long and 13 in. high outside dimensions. It is insulated with 1 in. of pressed corkboard and lined with 24-gage galvanized iron, which makes a water-tight joint with the outer casing. The case has two covers: (1) An insulated cover, which has a tapered edge so it will drop easily into place, and a flange to support it; (2) A protecting cover of 22-gage galvanized iron, strengthened at the edge with wire, and provided with hinges and a padlock hasp. The case is carried by means of a rope handle, secured to strap iron eyelets riveted to the sides of the case. The container for the sample bottles is a can 5 in. in diameter and 10 in. high, made of 26-gage galvanized iron, and provided with a slip cover 2-in. deep. The can is held in place by a galvanized iron bond attached just above midheight. The space around the can will hold 13 lb. of ice. If desired, a liter bottle can be packed in the can instead of eight 4-oz. bottles.

Hunting Faults in Water Mains

For the last few years the Water Department of the City of Baltimore has been conducting extensive investigations of the condition of underground structures along the city streets. The object is twofold: (1) To repair leaks and save water and (2) to replace old and weak pipes before improved pavements are laid.

Formerly the method was to tap a pipe at various points and with pitot tubes measure the pressure and the velocity of water flowing and thereby the volume. With all house connections closed between the points tapped the difference between the volumes determined by the pitot tubes gave a measure of the leakage.

It is now the custom to close all valves on a section of pipe to be tested and, with a triplex pump attached to the line, to subject it to a water pressure of 300 lb. per sq.in. If the pipe breaks, it is immediately replaced, thus saving the expense of ripping up improved paving a few years hence when the pipe would have eventually broken. A measure of leakage is also gained by this method by noting the drop of pressure per unit of time in the length of pipe tested.

A Suggestion for Making Water Rates

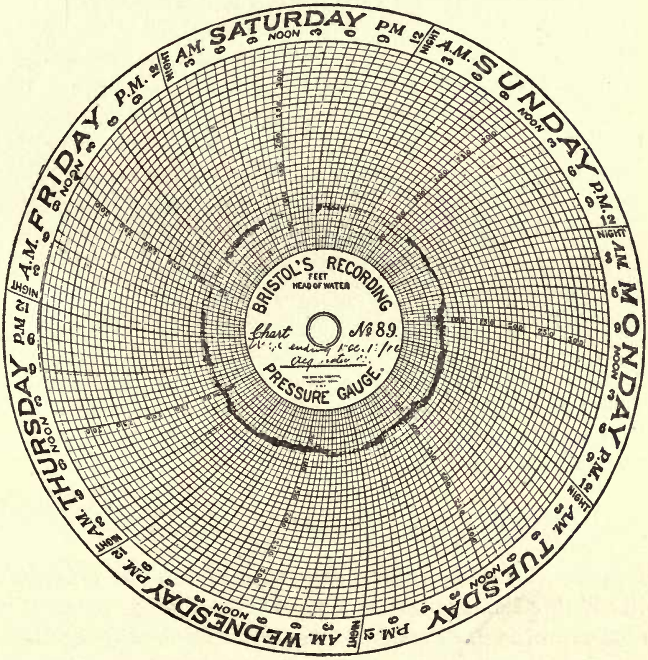
Compute the service charge by adding to a price per 1,000 gal. or 100 cu.ft., first $X\%$ on the cost of the meter and service pipes where owned by the company, then $Y\%$ on the cost of equipment required to meet the peak-load demand of the customer, then $Z for meter reading, billing and collecting, and finally $*A* to $*B* for unregistered water.

The reasons for such a suggested procedure need little exposition. There are two kinds of water-works: (1) The product-dispensing type, which pumps at a small steady rate, or collects as nature furnishes, and delivers out of adequate storage at varying rates; (2) the service type, which maintains pump pressure all the time and has power apparatus enough to meet its peak-load demands. For the first type of water company the $Y\%$ mentioned above becomes insignificant—even disappears, for the peak-load equipment consists only of a possible addition to diameter of mains, and even this may be absorbed in the provisions for fire protection.

Paying attention to the *Y* percentage in the case of the service type of water-works automatically clears away much of the worry about manufacturers' rates. If an industrial customer does not draw during peak-load hours, *Y* may disappear so that an attractive rate can be made to him that will still render a respectable profit to the water-works—or, where profits are not sought, at least make a more continuous use of plant and increase the spread of investment charges. This would be a development parallel to the success of electric central stations in building up off-peak commercial loads.

Pressure Constant Under Varying Draft

The accompanying charts indicate how the pressure in the mains of the Passaic water-supply system is maintained nearly constant,

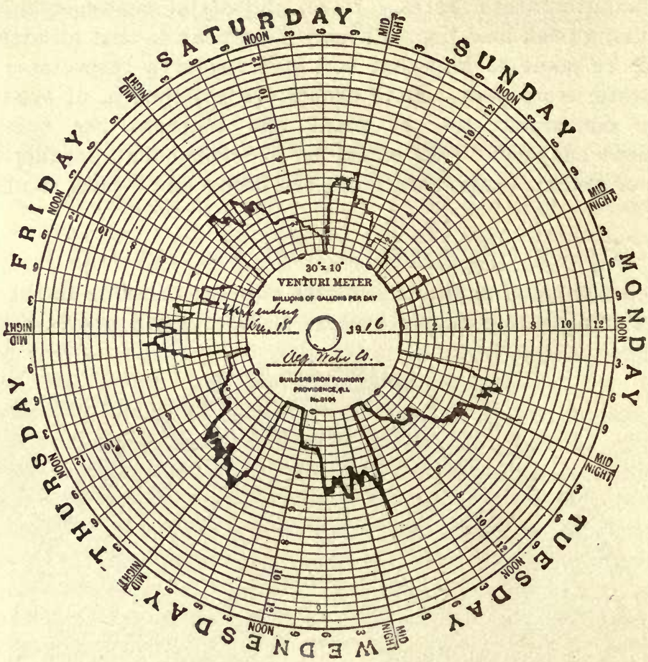


Regulator Valve Holds Pressure Constant

in spite of the varying draft, as shown in the second chart. The amount delivered varies in rate of draft from nothing to about

8,000,000 gal. per day. As may be seen from the chart, the variations are sudden and irregular.

Water is taken through a 16-in. regulating valve. The upstream pressure at the connection is about 100 lb. per sq.in.; it is reduced



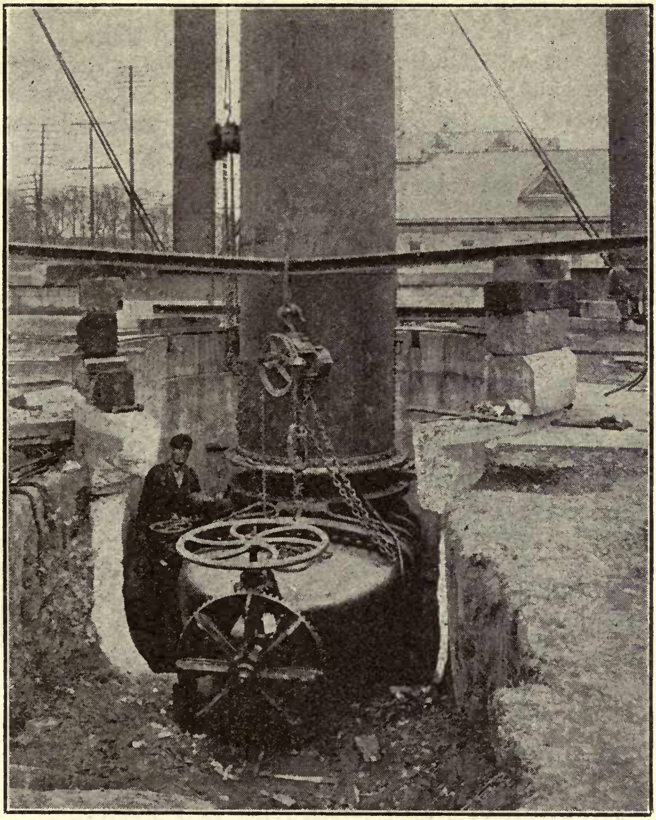
Rate of Draft Varies from 0 *to About* 8,000,000 *Gal. per day*

to 30 or 40 pounds. Water passing through the regulator valve is taken from a 51-in. main and delivered to a 30-in. main. The connection was installed in 1908 and has been operated continuously and satisfactorily since that time.

48-In. Valve Placed on Riser Pipe

The large elevated water tank at the filtration plant of the Louisville Water Co., Louisville, Ky., was originally installed without a valve between the 48-in. water-main connection and the 52-in. riser pipe. The steel riser pipe recently commenced to show signs of deterioration, and it was decided to put in a valve at the base so that the riser could be cut out for repairs without interference with the connecting mains.

The method of procedure was as follows: The expansion-joint connection at the cylindrical bottom of the tank was fixed so that



Placing 48-Inch Valve in Water-Tank Riser Pipe

there would be no movement. This was done by taking out every other bolt in the flange connection and inserting plates of steel which would completely prevent the riser pipe from moving.

Large Reservoir to be Sealed by Sluicing

What is probably the largest task of reservoir-bottom sealing ever attempted has been undertaken by Seattle, Wash. The reservoir to be sealed has an area of about 200 acres. The foundations of the dam across Cedar River which forms the reservoir are on bed-rock.

However, for a distance of over a mile, the north bank and the bed of Cedar River show a considerable leak, which appears through 4000 ft. of gravel in about sixteen days.

Drilling in the neighborhood of Cedar Lake has shown at least 8,000,000 cu.ft. of excellent clay, and drilling in the lake itself has shown that the greater part of the material on which it rests is blue clay, although the north bank of the lake has naturally silted against material similar to that which is now to be treated. The waters of Cedar River running into the lake are absolutely clear almost the entire year, and at such times as they are not clear the silt all settles in the lake so that the new basin cannot seal of itself.

A pump with a capacity of 4000 gal. per min. is being installed, and this is to be connected to about one mile of 16-in. pipe, which will carry the water to an elevation of approximately 350 ft. for the sluicing out of the clay bed which has recently been discovered. The material will be carried over grizzlies, the bars of which will be set close, as only the fine material is required. This will be carried back to the north bank of the river and along the distance to be treated. The bank is steep, and a considerable amount of material has to be sluiced into the river bottom in order to get the proper grade for silt to remain on the surface. The water, with clay in suspension, under the 350-ft. head above mentioned, will be used in sluicing the gravel from the bank and in this way will be incorporated with the gravel at the bank, the intention being to use about one part of clay to three or four parts of gravel. The first thousand feet next to the new dam will be treated first.

The present rate of seepage of the water is being carefully measured and a recording gage is being installed which will give the seepage from time to time as the sealing proceeds.

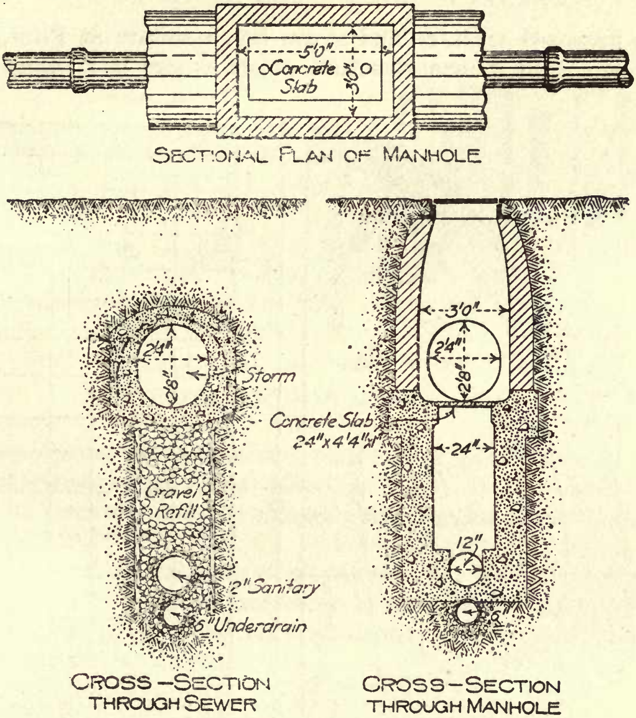
Interesting Solutions of Problems in Sewer Construction

Two Sewers Laid in One Trench

Two sewers have been constructed in one trench in Cambridge, Mass., since 1889, ranging in a great variety of shapes and sizes from a storm sewer 5 ft. 8 in. by 6 ft. over an 8-in. sanitary sewer to a 24-in. storm sewer over a 24 x 26-in. sanitary sewer.

In constructing the manhole no deflection in the alignment of the upper sewer is made, as the manhole is built to keep the flow separate and yet to give access to both sewers by constructing a removable bottom or floor slab in the upper chamber. In order to inspect and clean the lower sewer, it is necessary only to tilt up the floor slab by means of the two-ring bolts. This would usually be done when nothing was running in the storm sewer.

The drawing shows a rather interesting example of this type of construction on account of the unusual distance between the two sewers. Ordinarily, they are only about 2 ft. or less apart, thus



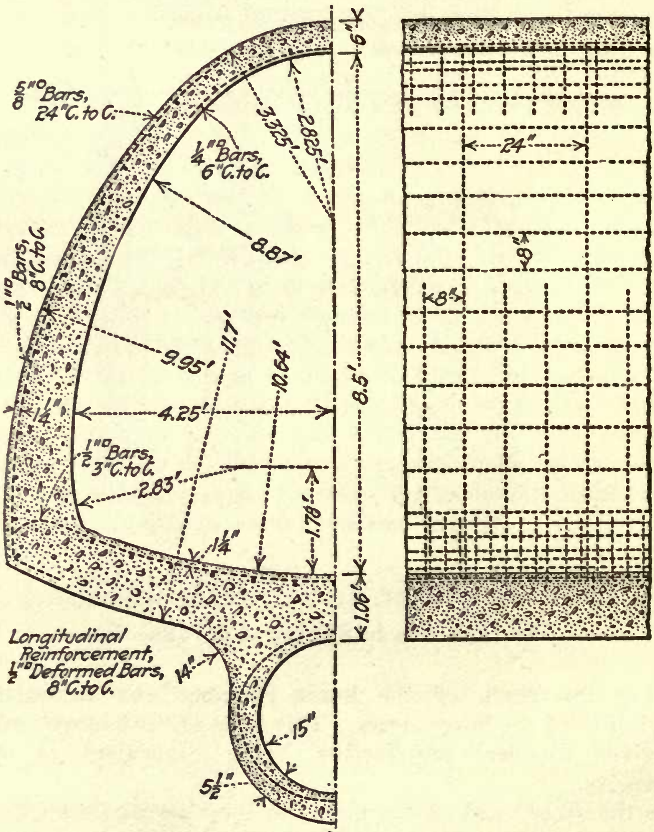
No Deflection in Alignment at Manholes

reducing the depth of the lower chamber and increasing the accessibility of the lower sewer. This style of "two-story" manholes has given excellent satisfaction, being convenient as well as inexpensive.

On the other hand, in the plans for the sewerage system of New Hartford, N. Y., the storm-water sewer was placed below the grade of the sanitary sewer, and with porous joints, to lower the ground water, thus enabling easier construction of the sanitary sewer and greater security against leakage, for the joints were made with jute and cement. For good foundation the sanitary sewer was laid on a shelf or shoulder cut in the side of the trench made for the lower sewer after that was laid and covered. The invert of the sanitary sewer was at the same elevation as the top of the other. Both have been continuously in operation and without trouble of any kind.

Combined Sanitary and Storm Sewers

The proposed sanitary and storm trunk sewers at Flint, Mich., will be combined in one structure except where it is necessary to

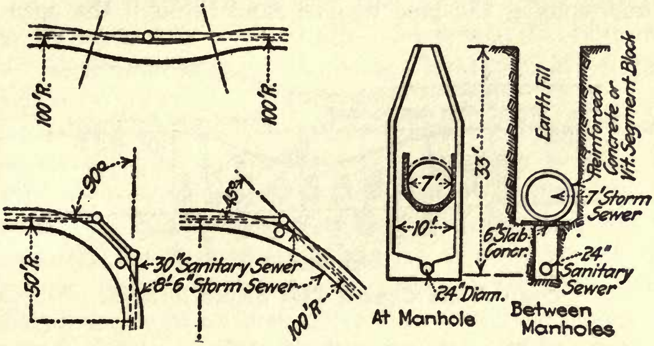


Cross-Section of Storm and Sanitary Sewers

have a manhole on the sanitary portion. At such intervals the following methods are used:

On a tangent a double reverse curve of 100-ft. radius is made in the storm-sewer portion only, thus separating in plan the two sewers a sufficient distance to permit the building of a manhole over the sanitary sewer.

At all angles in the alignment of the sewer a simple curve of 50-ft. radius is made in the storm-sewer portion only. The sanitary sewer is carried a sufficient distance beyond the P.C. and P.T. of



How Provision Is Made for Manholes

the storm sewer to permit the building of two manholes on the sanitary sewer in case the deflection angle of the sewer line is betwen 45 and 90°, and one manhole in case the deflection angle is 45° or less.

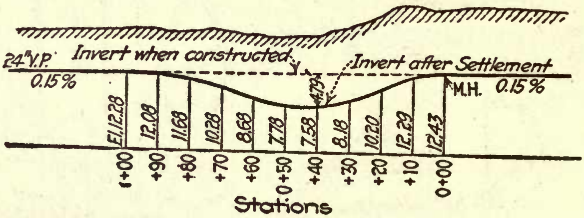
The type of construction proposed for that portion of the trunk line in which it becomes necessary to separate in profile the two sewers is illustrated. The maximum depth of sewer is 33 ft., and the minimum depth is 15 feet.

Calk Sewer Joints Under Some Conditions

Many engineers continue to construct storm sewers with open joints, basing their practice on the theory that the sewer is to remove surface water and that there is a further advantage gained by allowing all the water possible to enter the sewer by seepage through the open joints.

For some time the City of Cadillac has experienced difficulty in discharging the storm water through a 24-in. sewer that carries the surface water from a portion of the city. Several had "satisfied" themselves that it was being blocked by the accumulation of tar from the local gas plant, which discharged its waste water near this point. A thorough investigation made during the past winter showed the necessity of digging up the sewer. A profile taken of the sewer as found indicated that there was a vertical settlement of 4.79 ft. at a distance of 40 ft. from the manhole on an intersecting street. No variation horizontally was noted.

The sewer was laid on a small grade through low sandy soil. Due to the fact that it received a large amount of water during storms and spring thaws, there was a head of water sufficient to force through the open joints. The intermittent rise and fall of water surrounding the pipe washed sand through the open joints



Open Joints Caused This Sewer to Settle

into the sewer. This process, continued for a period of years, has caused the pipe to settle, thereby increasing the openings in the joints and completely undermining the sewer until it had settled more than two and one-third times its diameter.

Some lengths of the pipe were nearly filled with sand, but no evidence of an accumulation of tar was found. Most of the pipe was removed from the trench and relaid with joints calked with oakum and filled with cement mortar.

Measuring, Locating and Stopping Sewer Leaks

When the sewer system built for Bakersfield, Calif., in 1913-14 was completed, one line, comprising about 6600 ft. of 10-, 12- and 14-in. vitrified pipe, was found to be leaking badly. This line is located in low, flat ground, and the sewer, throughout most of its length, is covered by groundwater to a depth varying with the seasons of the year. The exact amount of leakage into the line was readily determined, owing to the fact that this sewer empties into a concrete-lined reservoir, from which the sewage is pumped to a gravity outfall sewer.

Series of Leakage Measurements Made

From measurements extending over a period of 24 hours in February, 1914, it was found that the leakage amounted to 70,500 gal. in 24 hours. At the time of this test, the groundwater was probably slightly above the mean stage. On Oct. 13, 1914, with the groundwater near its lowest level, the leakage was 39,075 gal. in 24 hours. From observations on the level of the groundwater at various points along the line of the sewer it was determined that infiltration was taking place at an average rate of 6.83 gal. per lin.ft. of submerged joint.

On May 11 and 12, 1915, a similar test was made. It was estimated that the top of the pipe was covered to an average depth of 3 in. throughout its whole length. The flow at this time amounted to over 121,000 gal. in 24 hours, giving a leakage of 15 gal. per lin.ft. of joint in 24 hours.

The method of repairing was as follows: First, the trench was opened and the pipe uncovered down to about its middle. The soil was then scooped out entirely around the pipe at each joint, leaving a series of oval-shaped depressions beneath the pipe. In the majority of instances the groundwater was at such a height that the depressions beneath the joints were only partly filled with water. In other cases the groundwater was high enough to render pumping necessary, certain portions of the line being entirely covered by water. As the soil at the depth of the pipe was almost pure sand, the flow of water into the trench was very great, and sheeting had to be done with considerable care. For the most part, ordinary 2-in. pine lumber was used.

After the joints for a distance of one block were exposed as described (or for a less distance when pumping was required), the pipe was tightly plugged in the manhole at the lower end of the block. Water was then introduced into the pipe above and allowed to flow down until the block of uncovered pipe was entirely filled. During the filling of the pipe a man was stationed in the manhole at the upper end of the block. As the stream flowed past him, he slowly sprinkled red aniline dye into the water, which was thus colored a bright red. This water, trickling into the little pools below the joints, revealed all the leaks, even the very small ones. The defective joints were marked as found, after which the pipe was emptied and the trench allowed to drain if, as was frequently the case, it became partly filled by the leakage from the pipe.

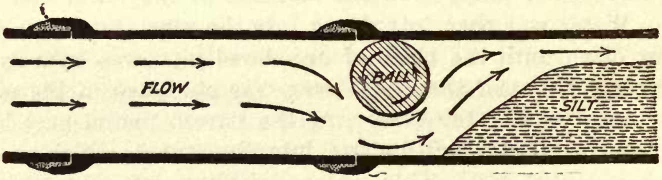
The defective joints were then carefully cleaned, and a thick collar of rich cement mortar was applied directly over the old joint. A strip of muslin about 9 in. wide was tied snugly over the cement collar to prevent its falling away from the pipe or being washed out of the joint by groundwater. It was found that fresh joints protected by this means were not injured by exposure to water where there was no current. Where water came into the trench in a quantity sufficient to make an appreciable current, no chances were taken, and it was kept down by pumping.

After the cement mortar had had time to set hard, the pipe was again filled with water, colored as before, and any leaks remaining were repaired and the trench backfilled. After the repair of the line was completed, several measurements of the infiltration were taken. A comparison of the infiltration before and after the repair may be interesting:

Date	Total Leakage, Gal.	Estimated Rate per Lin.Ft. of Joint Submerged, per 24 Hr.
Before Repairing:		
Oct. 13, 1914	39,075	9.6
May 12, 1915	121,000	15.0
After Repairing:		
Dec. 29, 1915, to Jan. 10, 1916, 12 days	1,200 per day	0.3
Feb. 10, 1916	12,000	1.5

Zinc Balls Clean Sewers

Some years ago a pipe sewer system was constructed in Owensboro, Ky. It was stipulated in the specifications that a ball 2 in. smaller than the bore of the pipe should pass through without lodging. In making this test on a certain section of sewer, the ball became lodged and had to be flushed to the manhole below. When the ball appeared in the manhole, it was found carrying a half brick before it. Appreciating the significance of this accidental discovery,



How the Ball and Water Clean the Sewer

this principle was applied to the cleaning of sewers. The writer for a number of years has used this method with excellent results. It is not successful where roots are encountered, but where silt and débris have collected in the sewer—due to the absence of flush tanks and catchbasins, or where the latter have been allowed to fill—this plan has been found to be cheaper than the drag or bucket method and entirely satisfactory.

When a sewer is flushed without a ball ahead of the stream of water, the sand or silt is pushed forward by the flow of water and the outlet is choked, thereby causing the water to back up and so lose its nozzle pressure; when a ball is used ahead of the water, the outlet is kept partly open, thus utilizing the pressure.

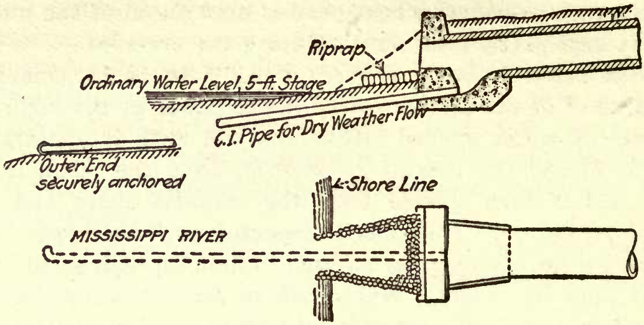
If the sewer is badly choked, a ball 5 to 10 in. smaller than the diameter of the pipe is placed in the sewer at the manhole and a stream of water applied behind the ball until it appears at the manhole below; the deposit is removed from the manhole, and a larger ball is then started from the manhole above and carried through as before. This plan is repeated until the sewer is clean. To insure a clean sewer, the last ball to pass through should be 2 in. smaller than the sewer. Where sewers are not badly choked, the first ball may be large, the size depending on the condition of the sewer. The ball should float and should be as light as is consistent with strength. Those used with best results are hollow and made of two thicknesses of No. 24 gage zinc, the seams being set at right angles. The sizes run from 4 to 22 in. Wooden balls have not proved satisfactory.

A fork or screen with a sandbag directly in front of it should be placed at the inlet end of the lower manhole. This is to prevent the ball, together with the silt expelled from the cleaned sewer, from escaping into the next section of sewer. A line of sewer should of course be cleaned in sections, beginning at the upper manhole.

Last year an abandoned sewer of 15-in. diameter was found to be almost filled with silt, there being a space of about 2 in. only at the top to allow passage of water. In cleaning this a 4-in. ball was first, and last a 13-in. ball. With the aid of these balls, 5 cu.yd. of sand was removed from this sewer in four hours.

River Outlet for Combined Sewers

In connection with a recently published report on sewerage improvements at Davenport, Iowa, a sketch for typical outlets to the Mississippi River was included which is reproduced herewith. The general scheme is sewage disposal by dilution. Where the inverts of the mouths of the various outlet sewers would be above ordinary water level a run of cast-iron pipe would take the dry-weather sewage to a submerged outlet. Where submerged dry-weather flow outlets are impracticable, vertical bar screens might be installed in the future; but these are to be avoided where and as long as possible on account of the trouble and



Proposed River Outlet for Sewage Disposal by Dilution at Davenport, Iowa

expense of cleaning the screens. It is thought that complete disposal by dilution will be practicable at most of the outlets.

What Engineers are Doing in the Fields of Flood Control, Irrigation and Hydraulics

Design of Flood-Retarding Reservoirs

A problem often encountered in flood-prevention studies is to determine how the flood flow of a stream will be affected by the construction of a retarding reservoir. The nature of this problem and the usual method of solving it have been stated as follows: The rate of outflow from the basin in a flood depends on the height to which the basin is flooded. This height in turn depends on the volume stored, which is the difference between the inflow and the outflow. Thus the quantities involved are inter-related. The problem of computing the outflow had to be solved by trial and error. This method of working is inconvenient and laborious. It may be avoided by the use of the solution given below.

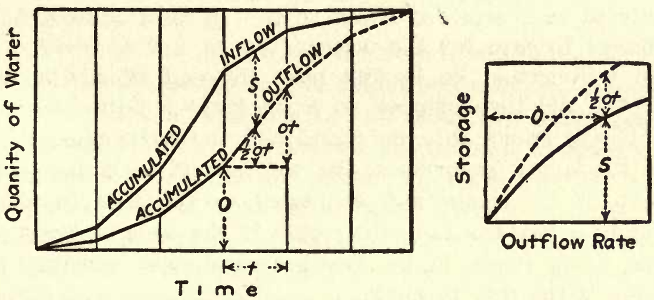
Notation: t = any short interval of time during the flood; o = rate of outflow from reservoir at any instant, or during interval t; O = total or accumulated outflow up to the beginning of interval t; S = total quantity of water stored in reservoir at any instant, or at the middle of interval t.

Given: (a) The original time-flow curve or flood-hydrograph of the stream, giving the rate of inflow into the proposed reservoir at each instant during the flood considered. (b) The depth-storage curve of the reservoir, giving the total quantity S of the water stored in the reservoir when the surface is at any given elevation. (c) The depth-outflow curve of the reservoir, giving the rate o of the outflow from the reservoir when the water surface is at any given elevation. This curve will be approximately parabolic if the outlet is a tunnel.

Required: The new time-flow curve for the stream as modified by the proposed reservoir, giving the rate o of the outflow which would pass from the reservoir during each instant of the flood considered.

Solution: From the original time-flow curve of the stream plot a curve of accumulated inflow at successive instants during the flood. This curve is the "mass curve" for the stream during the flood considered. Erect ordinates to this curve, spaced at a uniform time interval t so small that the curve will not vary sensibly from a straight line between ordinates.

Using the depth-storage and depth-outflow curves, construct a storage-outflow curve for the reservoir and on the same sheet construct another curve whose ordinate corresponding to any outflow o is $S + \frac{1}{2}ot$.



Storage-Outflow Curve Can Be Plotted from Accumulated-Flow Curves

If the accumulated outflow O is given at the beginning of any time interval t, the outflow curve may be extended through that time interval without the use of trial and error methods by taking from the first curve the outflow rate o corresponding to the value of the quantity $S + \frac{1}{2}ot$ as scaled from the middle of the time interval t in Fig. 1, and multiplying this rate by t to obtain the outflow ot during the interval. The method applies without change to the first time interval of the flood where O is zero. The operations may be carried out in tabular form if desired, without drawing the curves.

When the accumulated-outflow curve has been completed in the manner described, the desired outflow hydrograph of the stream may be readily obtained from it.

Small Wells Help Drain Irrigated Land

Rising wells or boreholes sunk below the level of tile drains may materially assist the drainage of irrigated lands that are underlain by shale. This applies particularly to such lands in the Rocky Mountain States, where the water in the shale is under pressure and where methods employed in other sections of the country have not proved successful. Deep tile drains are required, not less than 6 ft., and as much as 8 ft. deep in many cases. The depth to the water-carrying strata, however, is much too great for ditching; and as pressure conditions exist in these strata, the sinking of wells permits the water to rise into the drains.

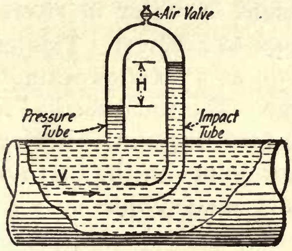
Owing to the character of flow in shale ground, the area of influence of a relief well is not large, and from two to six wells per 100 ft. of trench may be necessary. Their maximum depth is usually 20 ft. below the drains, and in general the flow is encountered at a depth of about 15 ft. In most cases a 2-in. hole is sufficient to care for the water.

The well should be located near the end of a tile, and one end of the tile then chipped so as to leave a 2-in. hole over the well. If the banks will not stand and the wells must be driven as the tile-laying progresses, the well should be a few inches to one side of the drain and connected to the hole in the latter by placing a half-tile over the well. If the well is directly under the tile, it is likely to be closed by sediment washing into it, especially if the flow is weak.

Modified Pitot Gives High Accuracy

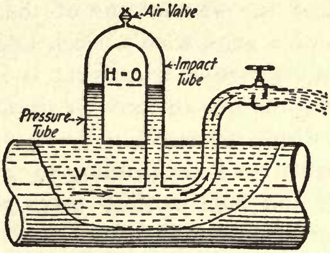
The pitot tube has long been used as a device for measuring the flow of liquids and gases, but only when used with the utmost care have the results proved uniform. Many experimenters have worked with modified forms in the endeavor to reduce the variation in results, but it is evident not only that the data obtained are variable in the hands of different men, but that the same tube may have different coefficients.

In order to correct this latter defect the "Hydraulic Shunt-Flow Tube," was devised. This device is a tube so arranged that it may be introduced into the stream with the tip directed against the flow and yet maintain at the tip the same pressure that existed before the introduction of the tube. The water flows into this tube and may be shunted into a small container and weighed, leaving the velocity undisturbed from the normal.



Common' Pitot Tube
FIG. 1

Formula:
$V = c\sqrt{2gH}$
H = Pitot Head
c = " Coefficient
g = Acceleration of Gravity



Hydraulic Shunt
(Modification of the Pitot Tube)

Formula: FIG. 2
$V = \frac{Q}{cA}$
Q = Flow from Tube
A = Area of Tip Opening
c = Tip Coefficient

Almost as Simple as a Pitot Tube

The velocity of flow at the tip of the tube will be equal to the quantity of water collected in the measuring tank, in a measured time, divided by the area of the tip—all quantities being measured in the usual units. It is possible to demonstrate mathematically that turbulent flow should not affect the coefficient of the tip. Theoretically, of course, the tip coefficient should be unity under all conditions, but a series of experiments undertaken with this in view show that it varies less than 1%—the pitot coefficient under like condition varying more than 4%.

Dams of Boulder-Filled Wire Baskets

Two hydraulic dams recently built in California consist of units, or baskets, of poultry netting filled with coarse gravel and rock These units are built in place and are laid like shingles on a roof. Into the netting are passed very coarse gravel and rock up to the size of a man's head. When a sufficient quantity has been deposited, the top is leveled off with a straightedge, and the selvage edges of the netting are drawn together by means of a piece of strap iron with a hooked end. The selvage edges are then fastened together with wire, and the ends are folded in and similarly fastened.

Discharge Plotted with Novel Curve

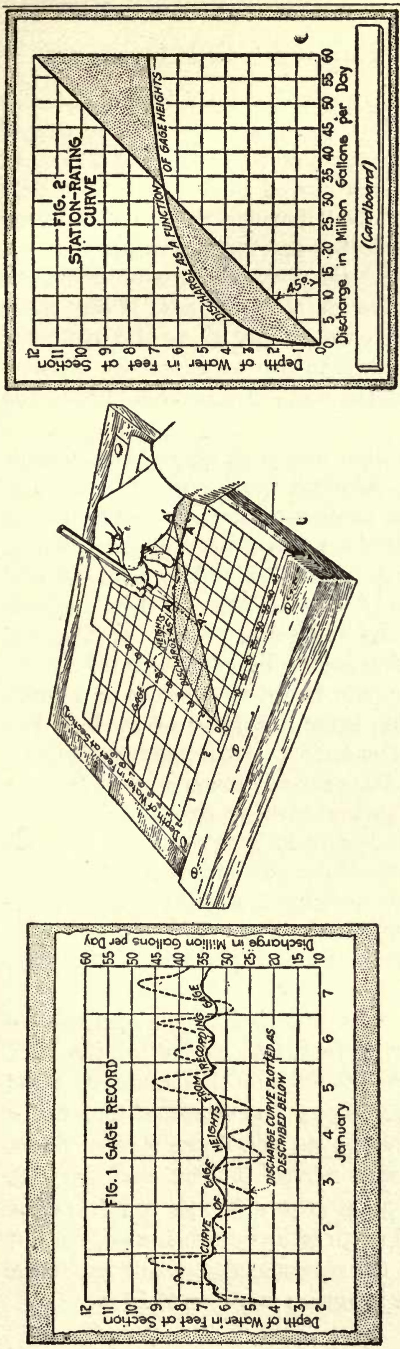
A quick and easy method has been developed for showing the variations in quantity of water passing a given point in a stream.

The common method of obtaining a continuous chronological record of the fluctuations of the height of water in rivers is by means of a gage with a clock and float attachment. This curve is used in connection with what is known as a "station-rating curve" to determine the amounts of discharge. The usual method of plotting a discharge curve is by reading from the station-rating curve the quantities corresponding to critical points on the curve of gage heights and then plotting these results against time on a separate sheet of cross-section paper.

The method herein described permits plotting the discharge curve on the same paper with the curve of gage heights. It also eliminates the time consumed in reading the gage heights, then referring to the station-rating curve to obtain the discharge, and finally plotting that value. This method presupposes the use of cross-section paper on the recording gage, as is usual with those gages which have a rectilinear rather than a circular movement of the recording pencil.

It is necessary, first, to plot the station-rating curve with the same scale of heights as is found on the gage-height record. Then draw a straight line from the origin at an angle of 45° with the axes. Next, cut out with a sharp knife the sections lying between the station-rating curve and this 45° line. Finally, paste a piece of cardboard at the bottom of this curve, keeping the lower edge straight and parallel to the horizontal axes.

This station-rating curve is then superimposed on the gage-height record so that the horizontal lines representing the same gage height coincide. A scale of quantities precisely like that on the station-rating curve is then laid off on the vertical axis of the gage-height curve, the zero of this scale starting at the origin of the station-rating curve. To plot the discharge curve, all that is now necessary is to move the station-rating curve horizontally along a straight-edge until it intersects the curve of gage heights at any point *A*. Then follow the vertical from this point until it in-



Sliding Diagram Permits Plotting of Stream Discharge on Gage Record

tersects the 45° line. This intersection A' is a point on the discharge curve.

Repeat this operation for all critical points A and then connect the points A' with a smooth, free-hand curve. This gives the discharge curve as in Fig. 1 plotted on the same paper with the gage-height record and corresponding to the time scale thereon. To determine the total discharge, planimeter the area under the discharge curve thus plotted.

That this method is correct is due to the selection and arrangement of the scales of height and quantity and to the fact that the ordinate of any point on a straight line passing through the origin and making an angle of 45° with the axes equals its abscissa. The operation of this method of plotting will be facilitated if the station-rating curve is made on tracing cloth and with no vertical or horizontal lines except the axes. The little extra time required in the preparation of the station-rating curve is many times recovered when plotting the discharge curve, especially if, as is often the case, the gage-height curve extends over a long period of time.

Movable Flume on Hydraulic Fill Dam

During the construction of a large hydraulic fill dam recently completed in the West, considerable time was saved by the use of an inclined runway for the flume from which material was deposited on the dam. Although the flume was moved by hand, it was only necessary to interrupt the flow for short periods while the delivery flume was skidded along the incline to the desired new position.

Three borrow pits were used, from which, by means of hydraulic giants, material was sluiced into three main flume lines. From these mains the material was conveyed through flumes along the upstream and downstream sides of the fill. By the use of gates the streams were discharged from the flumes at the desired intervals toward the axis of the dam.

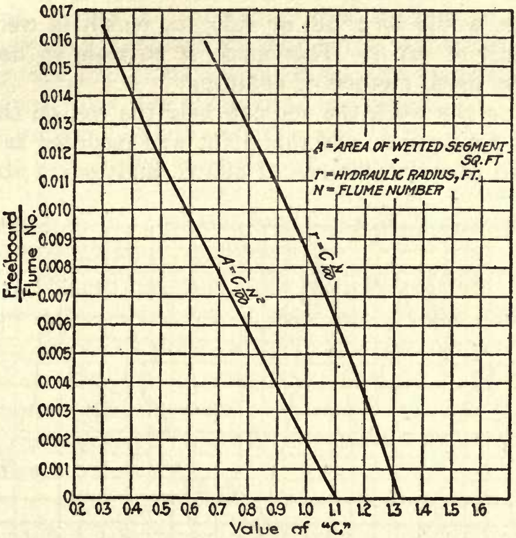
The flume box, 12 x 24 in. in section, was built up of 1¼-in. boards and was paved with 6 x 12 x 6-in. hemlock blocks set on end. Immediately above the blocks 1 x 6-in. projecting strips were nailed on either side. This box was supported on 2 x 6-in. stringers, which in turn were carried by 4 x 6-in. caps on the low sliding bents spaced 15 ft. apart and inclined on a slope of 5 to 1. The 6 x 6-in. inclined caps were supported on pieces of the same size resting on the material previously deposited and tied together by cross-bracing.

The flume proper was moved up the incline by means of a lever and chain device at each bent. The lever consisted of an iron bar near the lower end of which was fastened a chain connecting with the framing of the flume box. At the extreme lower end of the bar a second chain was attached which passed over an iron claw fastened to the upper end of the inclined 6 x 6-in. cap. This lever was operated by one man at each bent. With the lever in an upright position, pulling it down through the quadrant, which it was possible to describe, would move the flume up the incline a few inches. This gain was then caught by taking up slack in the chain at the claw, and the operation repeated.

Short lengths of lateral flumes were attached to the openings in the upstream side of the flume box to facilitate control of the flow. Doors for closing the openings were provided so that material could be discharged at any desired point along the crest of the fill, a duplicate line of flume being used along up and down stream faces. Of course each time the flume was moved it was necessary to establish a new connection at the point where it was fed from the supply flume. Sluicing was carried on practically continuously night and day in order to save time, and the movable feature of the flume was considered to be a factor in the progress made on the job.

Hydraulic Elements of Semicircular Flume

The accompanying curves give the hydraulic elements of semicircular flumes, partly full, in simpler form than curves before published. They can be platted in a few minutes from the elements



Curves for Semicircular-Flume Computations

of circular segments of radius unity, tabulated in almost any book dealing with the flow in circular conduits, by using the commercial number of the flume, which is the length of the curved flume sheet in inches, instead of the diameter. The wetted perimeter, which is seldom used, can be easily found from the area, and the hydraulic radius or the curve can be drawn if desired.

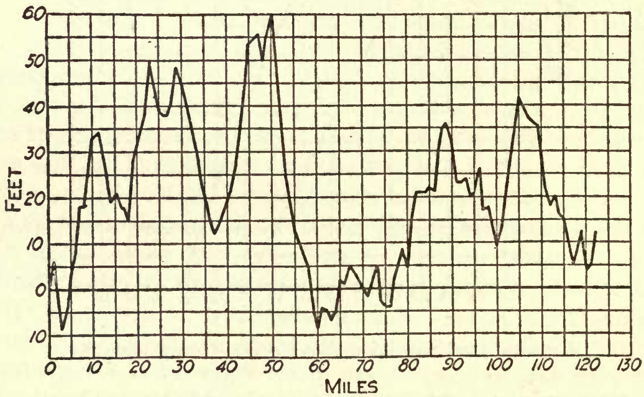
Practical Pointers for Railway Civil Engineers

Accurate Stadia Profile at Low Cost

A stadia profile was run last summer over the Illinois Central R.R. from Champaign to Centralia, Ill., a distance of 125 miles, for the railway-engineering department of the University of Illinois. Top-of-rail elevations were desired at intervals of 300 ft. for use in connection with grade-resistance investigations. The requirements that the stations should be tied-in to the mile posts and that the linear error in any mile should be not more than 10 ft., which is as close as the mile posts can be indicated on the dynamometer-car charts, were easily met.

Using 300-ft. sights, there would be 18 readings to each mile; hence, assuming an accuracy in the stadia readings of 1 in 300, the probable error in the length of a mile, according to the method of least squares, would be $\sqrt{18}$, or 4.35 ft., which is well within the allowable limit of error. This made it possible to use the stadia instead of the usual method of chaining.

In starting the work the rodman held the rod on the top of the rail opposite a mile post, and this point was recorded as Sta. 0. The levelman then paced a distance of 300 ft. and took a stadia reading



Compensating Tendency in Linear Errors of Stadia

with the instrument only approximately level. If the paced distance was within 5 ft. of that indicated by the stadia sight, the instrument was finally leveled, and accurate level and stadia readings were taken. Any error in excess of 5 ft. was corrected by making a new set-up. The rodman then advanced to Sta. 3, approximately opposite the instrument, and a level reading was taken.

The rodman then paced 300 ft. in advance and gave the levelman a trial reading for distance. The levelman signaled the correction necessary to locate Sta. 6, which point was marked on the rail with keel and used as a turning point. The process was repeated at distances of 300 ft. until Sta. 48 was reached. The instrument was set up as nearly midway between Sta. 48 and the mile post as could be determined by eye. Readings to Sta. 48 and to the mile post were made and added to the distance previously covered. In this way the distances between mile posts for 122 of the 125 miles were obtained.

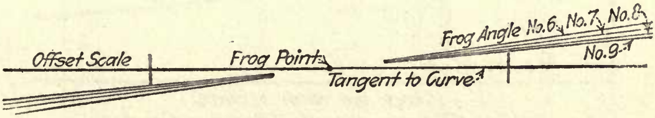
The distances between mile posts as given on the Illinois Central's official profile were assumed to be correct, and the differences between these distances and those obtained by stadia measurements were considered the errors in the stadia measurements. In very few instances were the mile posts 5280 ft. apart, as indicated by the railroad chaining. The distances between posts varied from 5265 to 5285 ft.; hence, not knowing what reading to expect, the observer was entirely unbiased in taking the last reading in each mile. In every case the stadia measurement was made and recorded before the chained value was taken from the profile.

The maximum error in any one mile was 14 ft. In 7 miles there was no error; in 67% of the miles the error was 5 ft. or less; in 96% it was 10 ft. or less, and the average error per mile was only 4.5 ft.—conforming closely to the probable error of 4.35 ft. expected according to the method of least squares.

As some of the errors were plus and some were minus, the accumulated error at no point was very large. The total error at the end of each mile has been plotted in the accompanying curve, and it is seen (1) that the largest error was 60 ft. at the end of the fiftieth mile, (2) that the error at the end of the one hundred and twenty-second mile was 12 ft., and (3) that at eight points along the line it was zero.

Laying Out Crossovers Between Curved Tracks

Crossovers between non-parallel curved tracks can hardly be located by any exact mathematical formula. Cut-and-try methods on paper on a large scale are the main recourse; but it is very difficult to lay out the flat curves without resort to geometrical construction, the lines of which would cover the paper if many trials

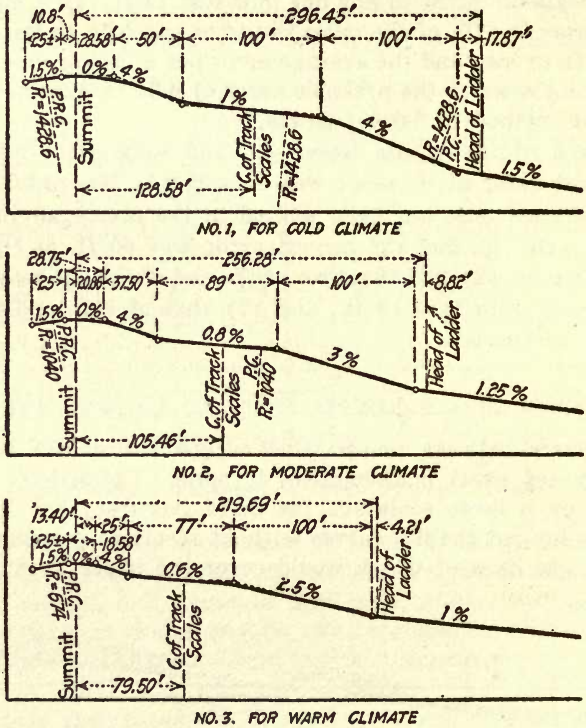


Templet Aids in Paper Locations of Turnouts

were made. A transparent templet like that shown can be used to advantage. The base line can be set tangent to the curve by the offsets, the circle being placed at the desired frog point, and the line of the frog can be laid or pricked off. Thus a number of trials can be made without confusing the drawing by any considerable number of lines.

Climate Should Govern Hump Profiles

Three hump profiles for gravity railroad yards, designed respectively for cold, moderate and warm climates, were adopted on the recommendation of the Committee on Yards and Terminals at the recent convention of the American Railway Engineering Association and will be substituted for the profile now in the "Manual." As the drawings indicate, 4% grades, reduced to 1% over the track scales, are recommended for cold climates while for more favorable climates the grades should be lightened or shortened, or both.



Colder Climates Require Steeper Grades

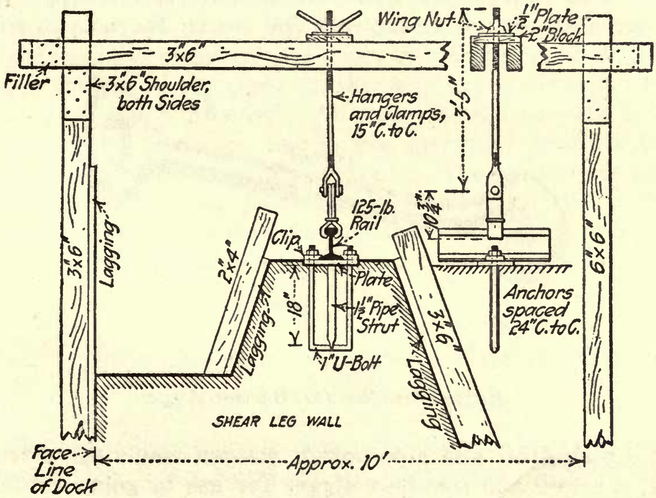
The committee points out that the problem cannot be solved precisely, since the speed developed by cars depends not only on the type of car, but, with the same type, on the length, whether loaded or empty, the lubrication, efficiency of maintenance, temperature, time standing before being pushed over the hump, head winds, care with which the tracks are brought to and maintained at the profile grade and, lastly, the timidity or assurance of the car rider.

In the estimation of the committee there are these seven salient features in the design of a hump:

1. A short grade steeper than the approach grade to bunch cars.
2. A level grade over the summit, these grades to be of such length as to form the tangent to a reverse curve connecting the approach grade with the first descending grade.
3. A short grade from the summit, to separate the cars quickly and give them the desired speed for weighing.
4. A light grade over the track scale.
5. A moderately steep grade, the rate and length depending on the traffic, to the end of the ladders.
6. A grade through the ladders sufficient to maintain the speed throughout the turnout.
7. A light grade that will just overcome in the length of the body tracks the speed already acquired.

Rails Located Before Concrete Is Cast

The sketch shows a method of setting U-bolts to hold down track rail by which much time was saved over spacing the rail with templets in constructing track for ore bridges at a Buffalo dock.



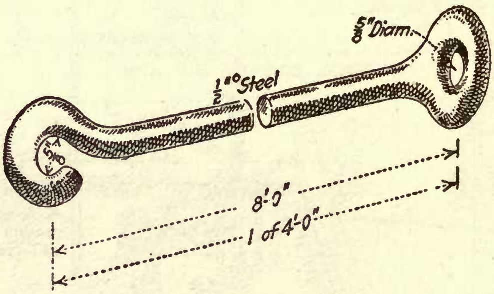
Rail Holds Anchor Bolts While Concreting

Altogether, 2400 ft. of 125-lb. rail was laid in this way. It is anchored by 1-in. U-bolts 24 in. apart, the ends of each bolt passing through a bedplate on which the rails rest, and the nuts on each side holding down cast-iron clips that retain the rail. To space these anchor bolts, templets of 2-in. pine were first used, but the method was abandoned after the completion of the first 120 ft., because it delayed concreting and there was difficulty in maintaining the bedplates at the proper elevation.

The method shown in the sketch, which involved hanging the rail in place before concreting, was substituted. A pipe spreader is used at each anchor, as shown in the sketch, to hold the bolt, bedplate and clips in position. The rail is leveled by the wing-nuts at the top of the hanger rods and lined by slipping the block under each of these nuts one way or the other, before concreting. While the concrete is still green, the top of the rail is checked for grade. Short 1 x 4-in. spreaders from the form studs to the web of the rail hold the latter to line.

Making Borings for Embankment Subsidence

Borings were made to test the subsidence of embankments in connection with the Government valuation of the Chicago, St. Paul, Minneapolis & Omaha Ry. The tools used on the work were a carpenter's 2-in. auger, a 2-in. pod auger, a short drill, two bars, 5 and 8 ft. long respectively, both of 1-in. drill steel, a supply of 2-in. single-strength pipe and couplings for casing the hole in soil that



Extension Bar for Boring Auger

caved, a pipe lifter and pipe holder, wooden mauls for driving the casing, a shovel and post-hole digger for use in going through the ballast, a short piece of heavy log chain with hook and eye, two pipe wrenches and a supply of extension rods. The augers and drill each had a shank 4 ft. long with an eye at the upper end so that an extension rod could be hooked on as the hole was lowered. These extension rods were of ½-in. round steel, 8 ft. long, with an eye at one end and a hook at the other. As some of the holes were more than 50 ft. deep, to unscrew joints every time the auger was pulled up for cleaning would have been slow work. With the hook connections the rods were disconnected as fast as they were pulled up, and there was no chance for sections to separate while in the hole. There was one rod 4 ft. long to use in connection with the longer ones, so that there was never more than 4 ft. out of the ground at a time.

The method followed in making these tests was to put a hole through the ballast with the shovel and post-hole digger, then set in a length of the 2-in. casing and use the auger the rest of the way, lowering the casing as the hole progressed. If the fill was of clay or any material that would stand without caving, it was often possible to complete the hole with only the one piece of pipe, as that would keep the ballast out of the hole. Where the fill was dry sand, or if there was water on the sides of the fill, it was necessary to keep the casing close to the bottom of the hole; and in some holes better progress was made with the casing driven lower than the hole, the material being bored out inside of the casing.

In a number of holes small gravel stones were found which caused a great deal of trouble, until the writer had a 3-ft. piece of 1½-in. pipe (the largest that would go inside the 2-in. casing) fitted with an eye at one end so that the extension rods could be hooked in. This pipe was churned up and down in the hole until the gravel had become wedged in the pipe. In this way any stone that would go in that pipe could be removed. At times the stones were too large to be removed in that way, and it was necessary to drive the casing down until the stone was wedged in it. The casing was then pulled and cleaned. In some holes it was possible to replace the casing without losing any of the hole, but at other times it was found that from 5 to 50% of the hole had filled and would have to be bored out again.

How Softened Concrete Lining To Tunnel Will Be Repaired

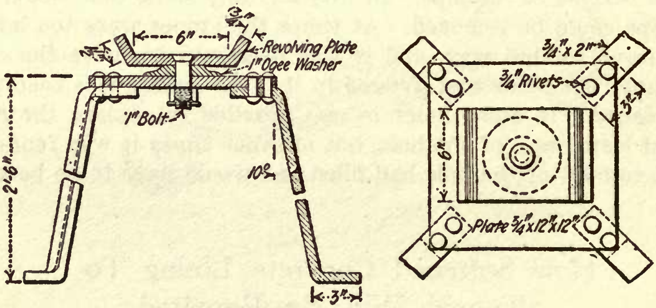
Plans have been made to repair the concrete lining to the Cascade tunnel of the Great Northern Ry., which has softened due to the formation of sulphur compounds from sulphur in the locomotive gases and the cement. As the lining was put in principally to protect the rock face against disintegration and not for strength, and as the steam locomotives are now superseded by electric traction, it is thought that repairs made now will be permanent.

The proposed method of repair is as follows: (1) Clean the entire area of sidewalls and arch, removing all disintegrated portions. After cleaning, the surface of the concrete is to be sprayed with an alkaline solution for neutralizing the acid in the concrete. (2) Drill 2-in. holes where necessary to provide additional drainage. (3) Drill 4-in. holes in the arch where necessary and fill cavities existing back of the concrete lining with sand filling or grouting. (4) Replace all disintegrated portions of the lining with a coating of concrete by a cement gun. The specifications provide that where the coating is over 3 in. deep it shall be supported by wire mesh cut to fit and fastened to the old concrete by spikes driven into holes drilled in the concrete 24 in. apart. The mixture for use in the cement gun will be one part portland cement and 3½ parts sand, mixed dry.

Turntable for Handling Relay Rails

The turntable shown in the accompanying sketch is proving a big labor and time saver in handling rails for the new car-repair yard of the Pennsylvania R.R. now under construction at Greenville, New Jersey.

The 85-lb. rails used are second-hand, and the ball of each is badly worn on one side. Since it is therefore necessary to place the unworn side on the inside of the track being laid, it happens that many



Device Saves Much Time in Handling Old Rails

of the rails have to be turned end for end before placing them. Previous to building the turntable it required considerable maneuvering by a gang of at least six men to turn one rail. With the turntable, however, which is set up about 18 ft. from the track being laid, two men can turn a rail with ease. The device was made complete for $8.

Open-Tank Creosote Treatment of Timber

Open-tank treatment of timber is desirable for interurban and the smaller steam railroads that have a number of timber bridges and other timber structures to maintain. Such a plant is convenient for treating fence posts, paving blocks and the like on very short notice.

The Virginia Railway and Power Co. has operated an open-tank treating plant at Norfolk, Va., since May 1, 1914, using dead oil of coal tar from its own gas-works as a preservative. Water-gas tar was tried as an experiment for a few months and finally abandoned because of the small saving and its doubtful value.

Yellow pine, mostly of merchantable grade, has been the only species of timber treated in the open tank, and has varied in size from 2 x 4-in. to 14 x 14-in. timber of all lengths. A number of pine poles have also been satisfactorily treated. The penetration obtained has been from 12 to 20 lb. per cu.ft. of timber. Well-seasoned timber is desirable for open-tank treatment; in the case of green timber it is necessary to keep it in the tanks until it becomes well seasoned from the heated oil.

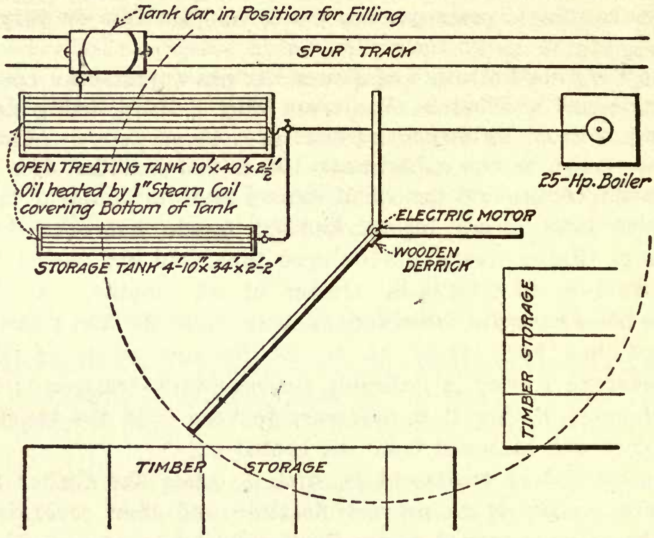
The method of treatment is, first, to place the timber in the tank and weight it to prevent floating, and then cover it with oil. The steam is turned on for about eight hours, at approximately 100 lb. pressure, the oil being kept at about 200° F. The steam is then cut off and the oil and timber are allowed to cool over night. The next day the timber is removed from the tank and placed on the storage piles by the derrick boom.

The following figures give the actual cost of treating at this plant for one month. One foreman (who also operates the electric derrick) at $3, one fireman at $1.50 and four laborers at $1.50 per day are required, working under the bridge supervisor. A total of 39,098 ft. b.m. was treated. The costs were as follows:

Item	Total	Cost per M Ft. B.M.
Dead oil of coal tar, 7375 gal. at 6½c	$479.38	$12.23
Coal, 6800 lb. at $3 per ton	9.10	.23
Labor, including foreman	83.50	2.14
Maintenance of plant	20.00	.51
Interest on $3000 investment	15.00	.38
Total expense for one month	$605.98	$15.49

Average penetration, 19.6 lb. per cu.ft. of timber.

The drawing shows the layout of the treating plant. The smaller tank is used for treating only in emergencies. The dead oil of coal tar is brought from the gas-works in a 2200-gal. tank-car that is fitted with a section of pipe to allow filling the treating tanks directly.



Treating-Tanks Filled Directly from Car

This company is very well satisfied with the results obtained. Of course, the company is unable to determine the life of this newly treated timber, but is expecting a life of at least 15 years for bridge timbers, and the same from ties when protected from mechanical wear by tie-plates.

Overbreakage Payment in Thorough-Cut

If, in railroad thorough-cut construction, the solid rock excavation be divided into two classes, (1) material within the slopes, (2) breakage, and if prices be fixed on both classes, the price on the latter (breakage) being sufficient to reimburse the contractor for handling this material but not large enough to warrant the excessive use of explosives, the result should be beneficial to both parties to the contract.

The railroad company will pay no more for the breakage than it is worth in the embankment, and the contractor can use enough powder to break the rock to the slopes, thus avoiding expensive trimming, without being up against the judgment of the engineer as to whether or not he will be paid for the material outside of the slopes.

This "in the judgment of the engineer" clause about the use of powder and breakage often leads to two bad results: First, loose stones are left hanging to the side of the cut, which should be taken down under construction, but are not and consequently have to be removed under operation. They frequently fall on the roadway and sometimes cause a serious wreck. Second, expensive controversies which may lead to more expensive lawsuits are the logical outcome of this "in the judgment of the engineer" clause.

Safe Stresses Shown by Broken Timber

The occasional failure of the stringers of pile bridges has been found to be pretty definitely related to the weight of locomotives operating over them. On the Atchison, Topeka & Santa Fé Ry. two kinds of stringer arrangements exist on the line, heavy and light, and the more frequent failure of stringers in the light floor construction drew attention to this relation.

All spans are 14 ft., and the stringers are made of Southern (Texas or Louisiana) yellow pine 7 x 16 in. in section, except that Oregon fir is used on lines west of La Junta. In the heavy floors used on main line and important branches there are four pieces per rail, set side by side with 1-in. clear space provided by separator washers on the through-bolts. The light floor used on some branch lines has three-ply stringers. During the past years a number of breakages of sticks in the three-ply stringers has occurred. Only one stick breaks at a time; and thus the breakages do not mean accidents, although they call for immediate repair work.

It was concluded that reinforcement to four-ply construction is now needed on many of the branch lines. Studies of bending moments in stringers were made to give more certain foundation to this conclusion. Some of the failures are of the longitudinal shear or splitting type, and others are bending-stress failures. The stress investigations, however, were made with reference to bending moment alone.

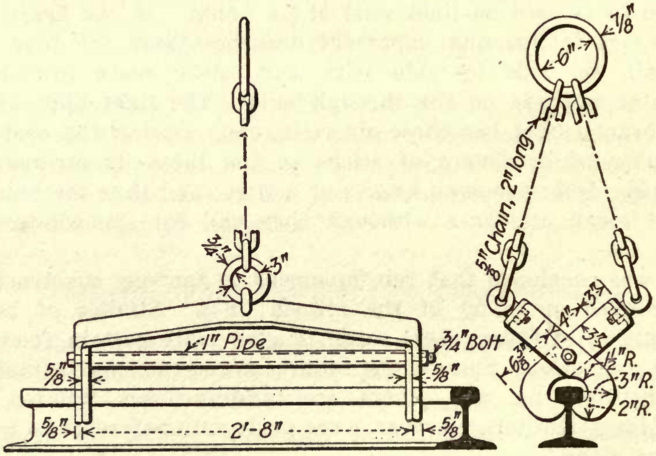
The first general fact was that locomotives whose total driver weights exceed 100,000 lb. for Atlantic, 140,000 lb. for Pacific and 157,000 lb. for Consolidation engines are likely to produce breakages in three-ply stringers. On the other hand, four-ply stringers gave no trouble anywhere on the system.

The railway company's standard bridge loading produces on 14-ft. span a bending moment equivalent to E-47 loading. It produces an extreme-fiber stress of 1400 lb. per sq.in. in four-ply and 1860 lb. per sq.in. in three-ply stringers. Various actual engines used on the line gave the following bending stresses in three-ply construction: 1520, 1780, 1824, 1792 and 1740 lb. per sq.in. These figures contain no allowance for impact.

The engines studied include some four-cylinder balanced compounds which produce a low impact effect, while others produce a high counterbalance-weight impact. Partly for this reason it was not possible to make a direct deduction from the facts. The final conclusion, however, was that bending stresses below 1500 lb. per sq.in. are safe, while loads whose static effect materially exceeds 1500 lb. fiber stress may produce breakages.

Special Tongs Prevent Rails from Seesawing While Being Handled

The sketch shows some simple rail tongs which have been developed on the Atchison, Topeka & Santa Fé Ry., and which have given good service. The length of these tongs, 2 ft. 8 in.



Tongs Hold Rails Steady in Handling

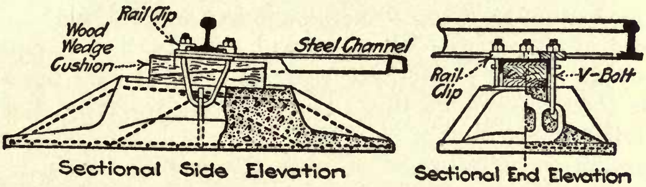
between grips, is found sufficient to prevent rails from seesawing while being handled by a crane. The main part of the tongs is made from $\frac{5}{8}$ x 3-in. soft steel, the jaws being hinged on a

¾-in. bolt with a 1-in. pipe spreader. Each half of the tongs is connected by a 2-ft. length of ⅝-in. chain to a large ring, which is hooked to the hoisting line.

Concrete Ties in Holland

An experimental track in which the ties are composed of pairs of concrete blocks connected by transverse steel tie-bars is in service on the Amsterdam-Utrecht line of the Netherlands State Railways, in Holland. In principle the tie resembles the ties tried in this country on the Chicago & Alton Ry., and the cast-iron plate ties that have been used extensively in India.

Each tie is composed of a pair of reinforced-concrete blocks about 4½ x 3 ft. on the base, with a maximum height of about 12 in. The top surface is about 36 x 18 in. with flaring ribs to the



Track with Concrete Blocks and Transverse Steel Channels; Netherlands State Railways

corners of the base, and its top forms a seat for a pair of wedge-shaped wood blocks. Upon the wood cushions of a pair of concrete blocks rests the ends of a transverse inverted steel channel. Upon this rest the 92-lb. T-rails and rail clamps.

At each block the rail is held by a pair of deep V-bolts, or stirrups, the loops of which pass through the projecting ends of cast-iron anchors embedded in the concrete. The threaded ends of the bolts pass through the rail clamps. In surfacing track the adjustments are made by loosening these bolts and adjusting the wood wedges, the concrete blocks being left undisturbed, as tamping is liable to result in causing cracks.

The weight is about 440 lb. for each block. The weight per lineal foot of track is about 1,500 lb., including ballast filled over the base of the blocks, but this weight for the experimental track is obtained at the expense of the support of the rail, the spacing being 4 ft. c. to c., or 2 ft. at the rail joints. Such wide spacing of rail supports is undesirable in track construction, and is only introduced to minimize the cost. The experimental track is only

120 ft. long. It carries considerable traffic, but the trains run at low speed, as it is near the city of Utrecht. It has been in service for about two years and is said to be generally in good condition, although cracks have developed in some of the blocks.

Oiling Flange Saves Rail Wear

On the New York, Susquehanna & Western Division of the Erie R.R. the rail wear on curves has been reduced two-thirds by the use of flange oilers on the locomotives, and tends to prevent derailments.

For success in the use of the flange oiler a very heavy asphaltum oil must be used. The oil should contain 40 to 60% of asphaltum in solution and be low in grease and paraffin. This heavy oil acts as a lubricant between the wheel flange and the head of the rail when a lighter oil would be forced out. Further than this, the heavy asphaltum oil sticks to the flange and will not work over onto the tread of the driving wheel, as will an oil with a paraffin base. Many of the troubles that have been experienced with flange oilers are due to the use of oil that runs over onto the tread and causes the driving wheel to slip.

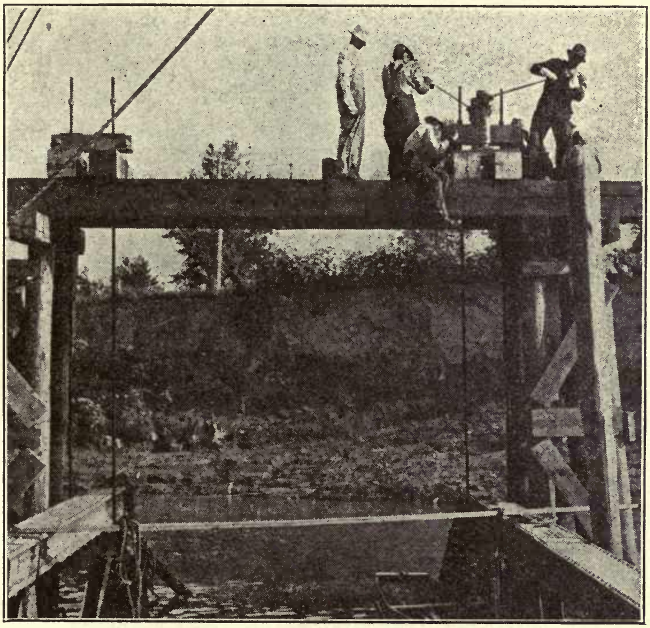
From an operating point of view, the saving in tire turning is even more important than the saving in rail wear. It has been estimated that the cost of tire metal used up, labor and loss of engine service every time a six-driver locomotive has to go to the shop for turning tires on account of sharp flanges represents an outlay of $219. Where freight locomotives not equipped with flange oilers will run 9000 to 12,000 mi. before requiring shopping to have their tires turned, they will run between 25,000 and 42,000 before shopping if equipped with flange oilers. In passenger service, locomotives that have to be shopped every 15,000 to 25,000 mi. should run 60,000 to 80,000 mi. if equipped with flange oilers.

Notwithstanding these practical advantages, the flange oiler appears to have as yet comparatively limited use. The reason apparently is inertia on the part of the operating force and dislike to equip locomotives with any appliances not absolutely necessary.

Raise Sunken Bridge Span with Jacks

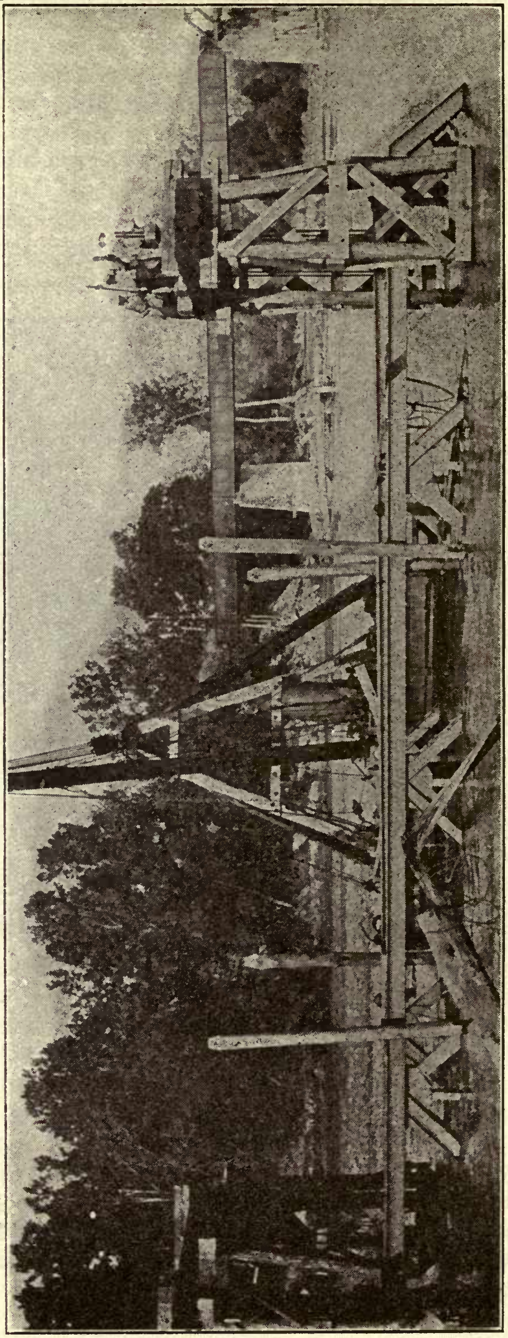
A ninety-foot pony truss span belonging to the Evansville & Indianapolis R.R., which was washed out on the White River near Rogers, Ind., was raised clear of the water without difficulty by the method shown in the photographs. The span had been carried about 1000 ft. downstream, and had landed in an upright position some 50 ft. from the south bank of the river. At low water the top 3 ft. of the trusses was exposed. The span lay in a nearly horizontal position.

Two gallows frames were erected, one over each hip of the span. The legs of these frames consisted of four pile towers, and the cross beams of six 8 x 16-in. stringers. Each hip joint was hung from a pair of 1½ threaded rods 18 ft. in length. Above the cross



Nuts Were Used To Adjust Jacking Yoke

beams each pair of these rods was connected by a timber yoke bearing under nuts screwed down on the rods. The raising was done with two 25-ton jacks, the nuts being used merely to adjust successive grips on the rods. The ends of the span were raised alternately, one jack being set over each joint, and each end being raised about 2 ft. at a time. After the bottom flanges of the floorbeams cleared the water by about 4 in. raising was stopped, two additional bents of falsework placed, and the span dismembered, the pieces being loaded on scows and taken to a repair shop on the north bank of the river.



Ninety-Foot Span Raised Alternately Two Feet at Each End Until Clear of Water

Relining a Tunnel Between Trains

A special concrete car with a high platform and a short tower, a jacking car for moving ahead the heavy forms, and work cars for removing the old timber lining and stone packing behind it, are being used in relining with concrete a single-track tunnel 5023 ft. long on the Union Pacific System at Aspen, Wyo., where about 20 train movements take place in the 10-hour day.

The tunnel being through material that exerts considerable pressure on the lining, the forms, made of 12-in. I-beams shaped to the tunnel section and spaced 24 in. apart, are set up first, and the roof load is transferred to them before the old timber is removed. There is a joint in each rib at each side on the springing line between the arch and post sections. To move the ribs forward, a jacking car is spotted at the right point under the roof, and the arch rib is raised from the legs slightly by taking a strain on a double-acting ratchet jack on the car. The legs are released and moved to the next location, the arch section is lowered till it clears the sides and top of the other ribs, and the car pinched ahead till the arch ring can be adjusted and bolted to the legs in their new location.

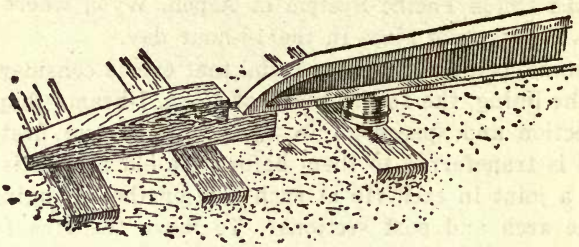
A special platform car is used in erecting these ribs, placing the reinforcing and removing the timber and old packing behind it. The platform is extended by hinged wings attached to the sides of the car, thus providing working space for the entire width of the tunnel. The wings are folded down when moving the equipment.

Another special car is in use placing concrete. On it are mounted a ½-cu.yd. mixer and a concrete hoist with a bucket holding one batch. The hoist elevates concrete to a platform 6 ft. below the crown of the arch. From this position it is spouted to place until the level of the platform is reached, after which shoveling is necessary. This car also carries water tanks and the cement. Aggregates are supplied in gondola cars and are handled by wheelbarrow.

By working three openings 200 ft. apart it is possible to keep one gang of men continually employed in form-rib erection, timber removal and excavation, while another gang is busy at concreting. At the same time the carpenters are building forms in the third opening. In this way each unit of the equipment works independently, the sequence of operation in each cycle is maintained at each point, and the work is all carried forward in one direction.

Wood Block Guards Third-Rail End

Trouble is sometimes caused by faulty third-rail shoes getting below end approaches and thus breaking the insulators and tearing up the rail. The accompanying sketch shows how this is prevented on one railway property by a wooden block placed in front of a



Guard To Prevent Third-Rail Shoes from Getting Under the Rail

third-rail approach and securely nailed to the ties. Sufficient clearance is left between the ends of the block and the rail to allow for the expansion of the latter. It has been found that no real harm results if the block accidentally comes in contact with the rail since the leakage is small even in wet weather.

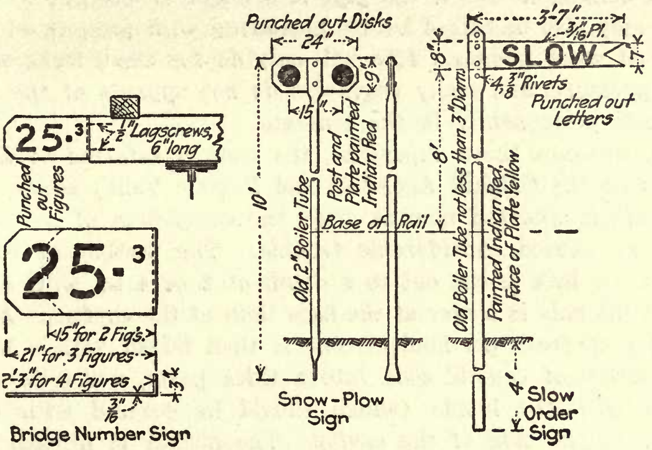
Photographic Survey of Proposed Route

A panoramic photographic survey of the route of the proposed Oregon, California & Eastern Ry. has been made in order to show the character and possibilities of the country to persons interested. The outfit used was a camera capable of making a picture 8 in. wide and up to 4 ft. in length. The camera revolves on the head of the tripod and is driven by clockwork so as to cover any desired degree of a circle. From a high point it was possible to cover a distance of 10 to 30 miles. In most cases it was found practicable to set up on a mountain or butte in such a position as to take a view from one valley to another, the points being selected by the engineer. Each picture was begun at about the point where the previous one ended.

It required 31 pictures, each 3 to 4 ft. long, to cover the entire route. This work consumed 19 days, as much time was taken in getting to and from the view-points. Pictures were taken only under favorable conditions of light, atmosphere and absence of wind, in order to get good results. After the photographs had been made, the chief engineer had a draftsman plot the line of the survey upon each picture, so as to show the cuts, fills, structures and other main features.

Metal Stencil Signs Need No Painting

Sheet-iron signs with the inscriptions punched out are being introduced by the Canadian Pacific Ry. to eliminate the cost of periodical painting and lettering. Such signs require nothing but a coat of paint at long intervals, and no painting of letters or numbers.



Track Signs with Figures Perforated Are Used by Canadian Pacific Railway

The bridge-number sign, a $\frac{3}{16}$-in. plate, attached to the end of a tie by lagscrews, costs from 75c. to $1. Mile-number signs are similar plates secured to telegraph poles. Such signs should last about 50 years. A wood sign costing $1.25 will last 12 years and has to be painted and lettered every three years at a cost of 75c.; for a 48-year period its total cost becomes $17.

Snowplow and whistle signs are fixed on boiler-tube posts. Two 6-in. holes are punched in the target for the former sign and a "W" for the latter. Metal "stop" and "slow" signs cost $2.75 each.

Helpful Suggestions from Recent Concrete Construction

Caustic Soda and Cement Stop Leaks

When leaks develop in concrete work it is generally too late in any case to remedy the cause, and the only thing left to do is to stop them, sometimes at the expense of considerable money to the contractor and worry to the engineer.

This is often done by piping the flow to one point, grouting in the pipe while it is passing the water, cutting the pipe off within the surface of the concrete and capping it, after which the hole left over the pipe is plastered up. This is a slow, expensive and puttering way of doing the job. Frequently the pipe rusts, discoloring the concrete and sometimes reopening the leak. There is always danger of this if the pipe is exposed to electrolytic action. Leaks may also be calked before plastering with jute, or with lead wool and wood wedges. Jute will only do for small leaks without much pressure, and many engineers do not approve of the use of wood left permanently in the concrete.

To overcome these objections, the method referred to was developed on the Catskill Aqueduct and Passaic Valley sewer, where leaks which occurred months after the completion of portions of the work caused considerable trouble. The section of concrete around the leak is cut out to a depth of 3 or 4 in. with a chisel so that the hole is larger at the base than at the surface. A small quantity of fresh portland cement is then mixed with a boiling-hot solution of caustic soda into a thick paste, which is applied rapidly with the hands (which should be covered with rubber gloves) to one side of the cavity. The plaster is pressed firmly against the old concrete and held for a minute or more. In this length of time it sets very hard and can only be removed with a chisel. This operation is repeated, following around the sides of the cavity, until a small opening remains, through which the water is now flowing. This small opening is again shaped with a chisel till the bottom is larger than the opening at the surface. Enough freshly mixed paste is then taken in the hand completely to fill this opening, and applied suddenly with one hand, holding the paste in place for a few minutes. If the work has been done well, the leak will be completely closed.

Practice is required for the successful use of this method, and there are several important points to be carefully observed. The soda must be of the best quality and fresh, very concentrated and mixed with very little water. The mixture must be boiling hot when the cement is added, and the latter must also be perfectly fresh. Very little of the paste should be prepared at one time, as it hardens almost instantly. Just enough of the soda solution should be used to make a stiff paste, which should be mixed very rapidly by kneading it with the hands.

One Year's Tests of Field-Made Concrete

Compression tests of 8 x 16-in. cylinders cast from concrete taken from forms have been made on practically all the work under the jurisdiction of the New York Public Service Commission, in connection with the construction of the new rapid-transit lines in New York City. The results of one year's series of such tests have been collected in the accompanying table, to which have been added for purposes of comparison the compression values prescribed by the final report of the Joint Committee.

RESULTS OF ONE YEAR'S TESTS ON FIELD-MADE 1 : 2 : 4 CONCRETE BY NEW YORK PUBLIC SERVICE COMMISSION*

	28 Days, Average Lb. per Sq.In.	No. of Tests Represented in Average	90 Days, Average Lb. per Sq.In.	No. of Tests Represented in Average	Increased Over Corresponding 28-Day Tests
Average of all tests	1725	84	2100	59	21%
Coarse Aggregate:					
Mixed Long Island beach sand and gravel	2155	11	2370	8	24%
Lond Island beach gravel	1880	10	2185	3	18%
Hudson River limestone	1880	10	2240	10	14%
Hudson River dolomite	1790	4	2280	3	23%
Hudson River traprock	1630	16	2035	10	17.5%
Long Island bank gravel (washed)	1550	31	1990	24	25%
Fine Aggregates:					
Sand excavated on the work	1775	9	2285	7	25%
Long Island beach sand	1690	24	2020	13	15.5%
Long Island bank sand (washed)	1610	38	2050	30	21%
Hudson River bank sand	1135	1	1837	1	62%
Consistency:					
Medium	2220	18	2425	14	10%
Wet (stiff enough to keep coarse aggregate from settling to bottom)	1710	47	2070	39	24.5%
Very wet (coarse aggregate settles to bottom)	1580	13	2300	1	33%
Extra wet (soupy)	1185	7	1320	6	10%
Mixer:					
Machine	1750	80	2100	59	21%
Hand	1290	4	....	..	....
Joint Committee:					
Granite and traprock	2200	..	....	..	....
Gravel, hard limestone, hard sandstone	2000	..	....	..	....
Soft limestone and sandstone	1500	..	....	..	....

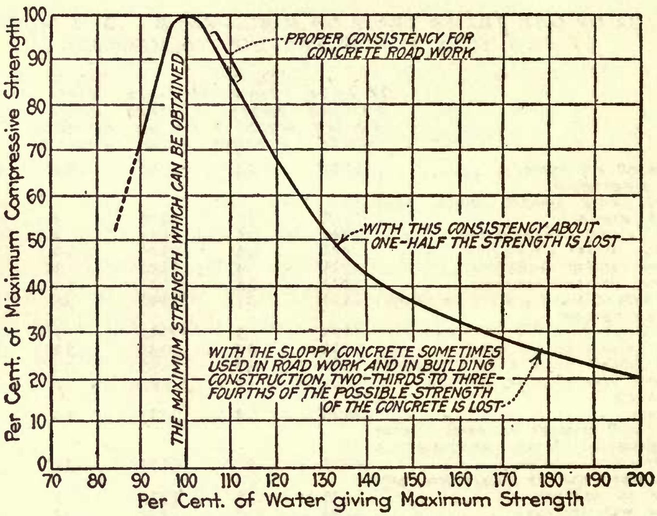
*All tests of doubtful accuracy have been omitted, and in computing the averages the result of any test that differed more than 50% from the average has been excluded. Each test consists of three specimens. Aggregates were specification material in every case. Dimensions of specimen cylinders, 8 in. in diameter by 16 in. high.

How Much Water for Road Concrete?

The proper amount of water to use in concrete to be placed in concrete roads is slightly more than the amount that will give a maximum strength. This is because the maximum-strength content gives a consistency that is too difficult to work, and a balance between strength and operating facility has to be made.

Tests were made at the Lewis Institute on a number of 6 x 12-in. compression cylinders, made in mixes ranging from one part cement and nine parts aggregate to one part cement and two parts aggregate. The aggregate consisted of a mixture of sand and pebbles graded in size from the finest particles up to 1¼ in., and the same grading was used throughout.

The tests show that the effect of proportional changes in the mixing water is approximately the same for all mixes of concrete. Therefore a composite curve was drawn to show the average effect.



How Excess Water Affects Concrete Strength

This curve is reproduced herewith. In it the ordinates represent the relative strength of concrete expressed as a per cent. of the maximum that can be secured from a given amount of cement and the same aggregate. The abscissas indicate the relative quantity of water used in the mix, considering the amount that gives the maximum strength as 100%. It will be noticed that there are no definite figures given, because the proper amount of water varies with the method of handling and placing the concrete, the condition of the aggregate, the temperature of the outside air and a number of other factors.

As a rule, the amount of water that gives the maximum strength produces a mix that is too stiff for most purposes, though in cast-concrete products a mix even drier than that which gives the maximum strength is sometimes desirable, because the molds can thus be removed within a short time. The general conditions, however, are shown in the curve. It will be observed that concrete strength increases rapidly with the quantity of water up to the optimum condition. With any further increase in the amount of water there is a rapid falling off of the strength, so that with an amount of water about double that required for the higher strength the concrete has only about 20% of the maximum strength.

In building concrete roads the consistency which is recommended corresponds to about 105 to 115% of that giving the strongest concrete. The economies resulting from handling the concrete are more important than securing the maximum possible strength for a given amount of cement. It has been observed that many road contractors insist on using water varying between 130 and 200% of that corresponding to the highest strength, with the effect on the strength noted in the curve. Had this curve extended beyond the 200% water, it would have been practically flat, thus indicating that the maximum of damage is caused at that point.

The proper quantity of water will vary with the quantity of cement and the size and grading of the aggregate, and to a less degree with the nature of the aggregate. The water required for a sand and crushed-stone aggregate is not appreciably different from that required of a sand and pebble mixture, provided the grading of the aggregates is similar. But there is no direct criterion for determining in advance the best quantity of water for

WATER REQUIRED FOR ROAD CONCRETE

Mix		Approximate Mix as Usually Expressed			Water Required (Gallons per Sack of Cement)	
			Aggregate			
Cement	Volume of Aggregate After Mixing	Cement	Fine	Coarse	Minimum	Maximum
1	5	1	2	4	6	6½
1	4½	1	2	3	5¾	6¼
1	4	1	1½	3	5½	6
1	3	1	1¼	2½	5	5½

concrete being placed on a road. The concrete should be mixed so that only a small quantity of free water will appear on the surface after leveling and striking off, which gives concrete of a jelly-like consistency.

The principal difficulty in the way of attempting to determine in advance the proper quantity of water is due to the fact that aggregates are generally damp, and the degree of dampness is not uniform. In the case of concrete made of sand and pebbles, or sand and crushed stone, well graded in sizes up to 1½ in., the accompanying table indicates about the quantity of water that should be used for the mixes commonly employed in concrete roads. It is assumed that the aggregates are in a room-dry condition, which does not always prevail in work.

Effect of Hydrated Lime on Concrete

The Bureau of Standards some time ago started an exhaustive series of tests looking into the effect of hydrated lime on concrete, as regards strength, consistency, watertightness and workability. A preliminary announcement gives some conclusions, based on six months' tests, as to the effect on strength. The results should be used with caution and hold only for hand-mixed, tamped concrete, of rather dry consistency and stored in a damp closet. There is no evidence at present to show the effect of the hydrate on concrete which is either machine mixed, poured or aged in air, and interpretation of the present conclusion to obtain such information is not justifiable.

The following conclusions have been reached: (1) The substitution of hydrated lime for cement causes, in general, a diminution of the compressive strength of the concrete. This is most pronounced with 1: 2: 4 concrete. (2) Hydrated lime causes a less diminution of strength in a 1: 1½: 3 concrete than in a 1: 2: 4. Results indicate that the sizing of the ingredients may be one of the important factors in determining the value of hydrated lime in concrete. (3) At least up to six months, there is no appreciable difference in behavior between high calcium and high magnesian hydrate. (4) The diminution of strength caused by hydrate when 1: 1½: 3 concrete is stored in air is not nearly so great as when the concrete is stored in the damp closet.

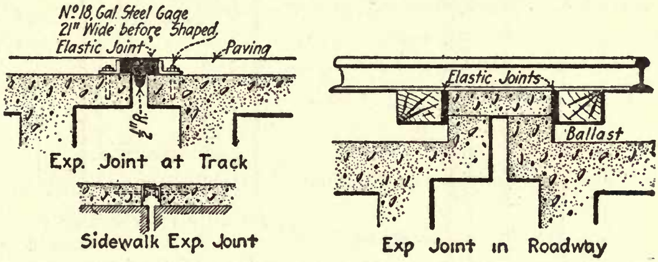
Link Expansion Joints on Viaduct

Measurements taken between extremes of temperature for a year on the linked expansion joints of the Colfax-Larimer viaduct in Denver indicate that all joints work as nearly equally as could be hoped for. The structure consists of alternate towers and suspended spans, the latter having lengths one-half the distance between bents and being supported by links upon the overhanging girders of the towers. With favorable results on the structure proper, on which to base the design of the joints in the pavement, the problem was to make provision for movement approximately every 80 ft., in such a way that there would be as little annoyance as possible to traffic. Plates or angles projecting in roadways are somewhat of a nuisance, and the thickness of the asphaltic pavement did not render a built-up joint feasible.

The joints adopted have undergone the test of an exceptionally severe winter in Denver, some being pulled apart at least ¾ in.

without as yet showing any need of repair; and as for ease of riding, a crack in an asphaltic pavement gives less shock to a vehicle than almost any other form of joint.

One other point in the design of the viaduct having to do with expansion, which has caused some anxiety, is the laying of sidewalk slabs of 4-in. thickness directly upon the old concrete of the superstructure itself. Although these slabs are completely severed by transverse joints at intervals of about 5 ft., they are monolithic with the curb; and there was some fear that, being exposed to the atmosphere, their rates of contraction would be different from that of the



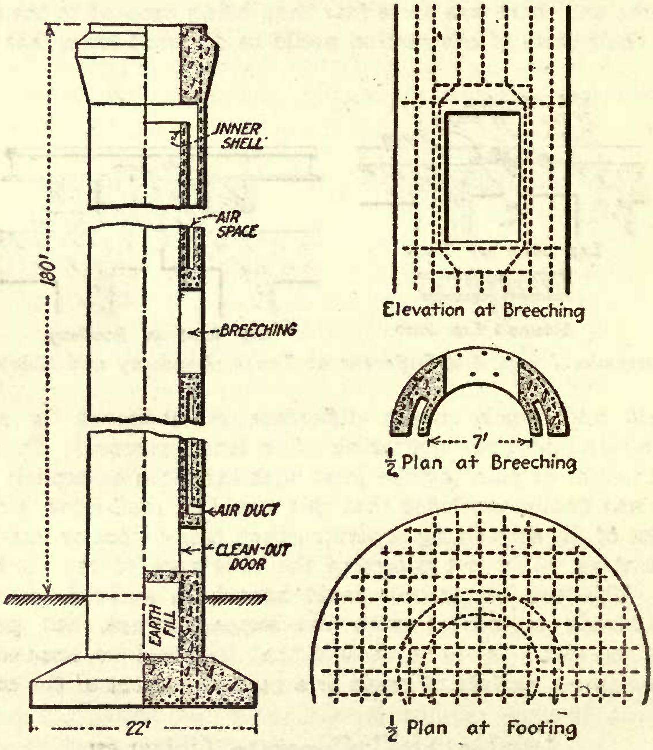
Expansion Joints Are Different at Track, Roadway and Sidewalk

concrete underneath, which difference might result in surface cracking and possible shattering after long exposure. There was some thought of painting the joint with tar pitch or asphalt paint; but it was finally concluded that this would be ineffective, since the concrete of the underlying superstructure, being more or less lumpy, the painting would not overcome the resistance of the mechanical bond. This possible trouble could have been avoided by making the sidewalk monolithic with the superstructure, but previous experience along this line showed that it would be impossible to obtain either a surface to grade or a good alignment of the curbing.

Double Shell Concrete Chimney

A special arrangement of the interior shell and the use of adjustable steel forms to give an exterior taper are the features of the reinforced-concrete chimney at the plant of the Rockford Paper Box Board Co., Rockford, Illinois. It is 187 ft. high with an interior diameter of 7 ft. throughout. The outside diameter is 10 ft. 4 in. at the footing and 9 ft. at the top, with a taper of 0.056 in. per foot, commencing at the top of the breeching. The inner shell has been carried nearly to the top in order to protect the outer wall and to improve the draft efficiency

If the gases are only slightly cooled and come in contact with a relatively thick portion of the outer wall, they heat its inner surface while the exterior may be exposed to very cold weather. As concrete is a poor conductor of heat, this condition results in severe internal stresses, and observations of many chimneys built in this way indicate that the most serious cracks occur about the level of the top of the short interior wall.



Concrete Chimney with Inner Shell Extending Full Height of Shaft

To create a draft in the air space, in order to protect the outer wall from high temperatures and to prevent the collection of soot, openings in the outer wall are made at the base of the air space. The inner wall is made as thin as practicable in order to minimize unequal expansion and is 4 in. thick for its entire height.

The thickness of the outer wall of the chimney illustrated reduces from 12 in. at the bottom of the air space to 4 in. at the top of this space (beneath the cap). In nontapering chimneys the variation in thickness is made by offsets on the inner side, but in this case the inner side is vertical and the reduction is made by the tapering of the outer side. This taper was given by the use of adjustable steel forms. These were in lifts 2 ft. high, and the diameter was reduced at each lift. The forms were found very flexible, and the same ones used for the stack were made to serve also for the enlarged head, or cap.

The concrete is a 1:2:4 mix, made with gravel ¼ to 1 in. in size. It was hoisted in buckets in an inside tower, which carried the working platform. The reinforcement consists of steel rods and hoops in each wall, the vertical rods being hooked to the rods in the base of the footing. This footing is built directly upon a stiff clay formation, no piles or other special treatment being required.

Results of Recent Tests in the Laboratory

Results of Wood-Decay Investigations

Field and laboratory studies of the U. S. Forest Service indicate that much more care should be exercised in the selection of timber and in the construction of buildings to avoid conditions favorable to decay. Any one of the following causes may result in rapid deterioration of the building: (1) Use of green timber, (2) allowing the timber to get wet during construction, (3) allowing the timber to absorb moisture after the building is finished because of leaks or lack of ventilation, (4) use of timber containing too much sapwood, (5) use of timber which have already started to decay. The avoidance of these conditions will, as a rule, prevent decay. In special cases preservative treatment is necessary, zinc chloride and sodium fluoride being better than creosote for buildings.

Studies to determine the extent to which lumber is attacked by fungi while seasoning in lumber yards are being continued. Specific cases were studied, showing how sound lumber is infected by partly decayed lumber before shipment is made. Simple rules were formulated for restricting the spread of fungus in lumber. Tests to determine the effect of various amounts of resin in the southern pines upon their durability indicate that it does not depend directly upon their resin content.

About 1500 pieces of wood, representing 50 different species, are under test to determine their relative durability. At the end of three years, all of the conifers with the exception of cypress, redwood, yew, and the cedars, have decayed, as have also most of the hardwoods.

Kiln-Dried Douglas Fir Timbers Tested

Bending tests were made upon four kiln-dried Douglas fir beams and minor specimens cut from them by the Forest Products Laboratory. Beams 1 and 2 were dried under high velocity, low-superheated steam, at a temperature of 225° F. for a day, 230° F. for the succeeding seven days, and 240° F. for the remaining four days. Beams 3 and 4 were kept at a temperature of 220° F. throughout the run, the steam being superheated for the first five days, when the humidity was reduced to 70%. During the next four days the humidity dropped gradually to 25%, where it was maintained during the remaining seven days. Beams 1 and 2 had a modulus of rupture of 6620 and 4910 lb. per sq.in. respectively, and beams 3 and 4 a modulus of rupture of 4740 and 6160 lb. per sq.in. respectively. All beams failed by horizontal shear due to the severe checking. The results are very encouraging for the development of the process for kiln drying Douglas fir beams in structural sizes.

Zinc Borate Retains Fire-Resisting Power

The Forest Products Laboratory has just fire-tested a small shingle roof section, painted with a zinc borate paint, which has been exposed to the weather for nearly three years—other shingles specially treated with the same paint being used as a control. The results show that the paint had resisted the action of the weather without losing its fire-retarding properties to any marked extent.

White Paint Saves Gasoline

In considering the effect of the different types of rays of which light is composed, it is found that the calorific, or heat-producing, rays are conducted by painted or finished objects in widely varying degree. This fact should be studied. When black or dark-colored paints have been used in painting large tanks containing light distillates, rapid absorption of heat takes place, and considerable losses by evaporation are apt to occur. White or light-colored paint should therefore be used for the finishing coats on oil-storage tanks. Paints presenting a high gloss are, moreover, less absorptive of thermal rays than those presenting a matte surface.

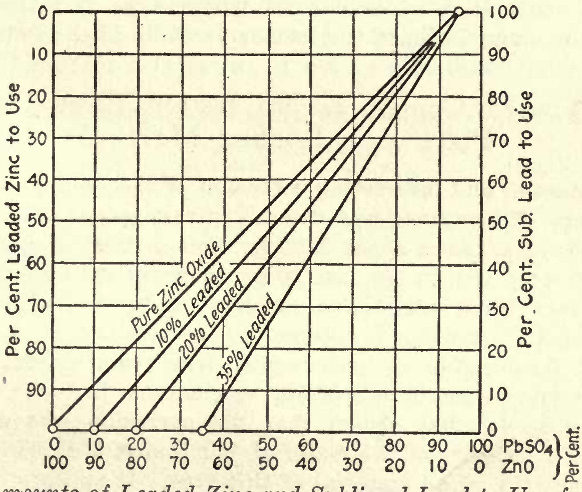
RISE IN TEMPERATURE OF BENZINE CONTAINED IN SMALL TANKS PAINTED IN VARIOUS COLORS (GLOSS FINISH), WHEN SUBJECTED TO HAYS OF CARBON ARC FOR PERIOD OF 15 MINUTES

COLOR	Rise in Deg.	COLOR	Rise in Deg.
Tin plate	19.8	Light gray paint	26.3
Aluminum paint	20.5	Light green paint	26.6
White paint	22.5	Red iron oxide paint	29.7
Light cream paint	23.0	Dark prussian blue paint	36.7
Light pink paint	23.7	Dark chrome green paint	39.9
Light blue paint	24.3	Black paint	54.0

Since white paints faintly tinted have given substantially the same heat-reflecting properties as white paints, the former should be given the preference, as they are more restful to the eye and more durable on long-time exposure.

The Lead Content of a Leaded-Zinc Paint

In states requiring the formula to be shown on paint packages, the lead content of all oxides excepting the lowest (under 5%) must



Amounts of Leaded Zinc and Sublimed Lead to Use for Desired Lead Content of Mix

be stated. In all cases where the lead sulphate is actually basic ($Pb_3S_2O_9$), this is properly given as "basic lead sulphate." On the other hand, if leaded oxide be used in which the lead content is practically all present as normal lead sulphate ($PbSO_4$), the propriety of the designation may be subject to question.

In practice it is often necessary or desirable to increase the basic lead sulphate content of the formula over that present in the leaded zinc available for use. Since basic lead sulphate (or sublimed lead) as marketed contains about 5% of zinc oxide, calculation of the required proportions of the two pigments required to yield the relative percentages is a rather complicated process. The accompanying chart will furnish the required information at a glance.

The figures to the left indicate the percentages of leaded zinc and those to the right of sublimed lead required to produce the required percentages of ZnO and $PbSO_4$ indicated at the bottom of the chart. The four diagonal lines represent the several grades of oxide. To find any desired percentages shown in the bottom rows of figures, using any of the oxides shown, follow the perpendicular line to its intersection with the proper diagonal; the required percentages of that oxide and sublimed lead will then be found on the horizontal line to the left and right respectively. For example: Desired percentages 50 each, using a 35% leaded oxide. The 50-50 perpendicular intersects the 35% diagonal at the horizontal line, which indicates at the left 76% leaded zinc, and at the right 24% sublimed white lead. The desired percentages will therefore be obtained by using 76 lb. of the former to 24 lb. of the latter.

Tinned Copper Is No Better Than Tin Plate as a Roofing Material

The unusual and interesting corrosion of the roofing material of the Library of Congress was recently investigated. This building has been covered since about 1893 by tinned sheet copper that has become covered within the last 10 or 15 years with small pits; in many cases these pits have extended completely through the sheet. Such a condition is interesting, particularly in view of the fact that Washington is uncommonly free from smoke, which is ordinarily understood to be a strong accelerating factor in corrosion. The investigation has shown that the corrosion was due to no accidental inferiority of the material, but that it is to be considered as characteristic of all material of this type. It appears, therefore, that tinned copper is not superior in any way to tin plate for roofing material and that in view of its greater cost can no longer compete with it.

Tinned sheet copper is used also for containing vessels such as milk cans and for fittings such as troughs, etc., for soda fountains and breweries. It is probable that such articles would also be subject to pitting corrosion of the same type if they were not worn out by actual abrasion before the corrosion had proceeded far.

To Prevent Volume-Change of Wood

Pieces of air-dried wood were treated in a variety of ways to determine the best methods of retarding their absorption of moisture from the air and loss of moisture when placed in dry air. Specimens were treated with paraffin, impregnated with sugar, heated at high temperature, painted, varnished, coated with bakelite, impregnated with creosote, etc. Curves have been drawn showing the relative shrinkage and swelling which took place in these boards when exposed over a period of a year to atmosphere containing various humidities. The most effective results were secured by coating the wood with paraffin. Excellent results were also obtained from high temperature treatments and by impregnating the wood with sugar.

Recent Pressure Tests of Welded Joints

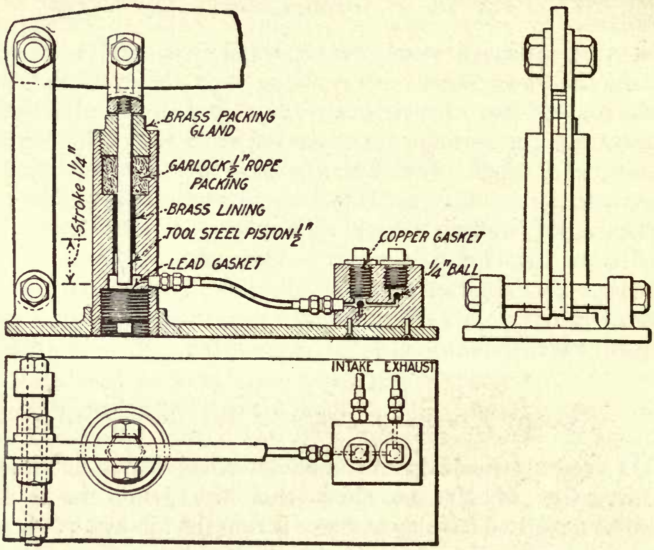
Tests recently made in the machine-construction laboratory of the University of Kansas show that the joints made by the oxyacetylene method develop average strengths against rupture from internal pressure as great as, if not greater than, those which may

TESTS SHOW SUPERIORITY OF WELDED CONNECTIONS

Size Pipe	Type Joint	Pressure, Lb. per Sq.In. At Failure	Maximum	Nature of Failure
2 in.	Welded T	4400	4400	Tube seam split
	Welded T	2200	2200	Leak in tube seam
	Welded T	4750	4750	Tube seam split
	Screwed T	2350	2750	Sand holes in fitting
	Screwed T	500	2000	Sand holes in fitting
3 in.	Butt weld	....	5300	
	Butt weld	4950	4950	Tube seam split
	Butt weld	....	4250	
	Coupling	3950	3950	Coupling split
	Coupling	3400	4400	Leak in coupling
	Welded T	....	3500	
	Welded T	....	4250	
	Welded T	....	3505	
	Screwed T	350	2700	Sand holes in fitting
	Screwed T	300	3100	Sand holes in fitting
4 in.	Butt weld	....	5100	Pipe bulged
	Butt weld	....	3250	
	Coupling	300	3000	Leak at threads
	Coupling	750	2600	Leak at threads
	Welded T	3850	5100	Leak in weld
	Screwed T	1000	1950	Sand hole in fitting

be ordinarily expected from screwed pipe connections. The data given in the accompanying table are supplementary, but confirmatory of similar figures determined about a year ago.

The results indicate that the strength of a welded pipe connection is practically the same as that of unwelded pipe; and although careless welding might result in a leaky connection, if the line be tested when installed it should be immune from trouble in service.



Special Pump Carries Pressure Over 5000 Pounds

A special high-pressure pump of simple detail was designed and built for this work. It was connected to the specimens under test by means of a ¼-in. copper tube. A pressure gage, with a check valve opening toward the gage, was located on the tube—the valve being necessary to steady the pressure in order that satisfactory readings could be obtained, because some of the samples carry pressures greater than 5000 lb. per sq.in. before failure.

Dense Wood Gives Nails High Values

Tests of the efficiency of various types of wooden joints were made, and about 3000 nail-pulling tests were completed on nails driven into twenty-five different species of American timber. While the data have not been fully analyzed, it appears that the holding power of nails has a definite relationship to the density of the wood, and that there is practically no difference in strength between a solid beam and a wooden beam of the same dimensions made of two planks nailed together.

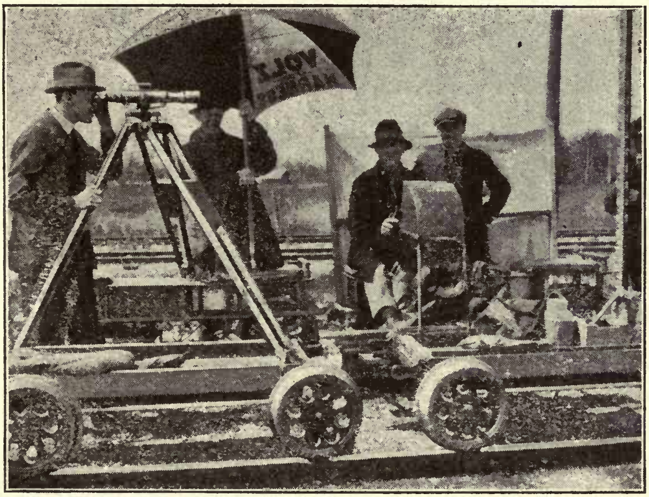
Practical Hints for the Surveyor

Small Motor Cars on Precise Level Work

Motor driven cars with flanged wheels for use on railroad tracks carry the outfit used by the United States Coast and Geodetic Survey in that part of their work which is upon railroad rights of way.

An interesting novelty is the adding machine attached to one of the cars for recording the reports of the parties engaged in precise leveling. A rigid frame, which holds the calculating device, is bolted to the body of the car. The operator is provided with a comfortable cushioned seat over the wheel, where he can do his work conveniently. The added reliability and greater speed of the machine for noting the readings of the level rods makes it a valuable addition to the equipment of parties in the field.

Another car carries the level, the tripod being securely mounted upon the frame of the motor vehicle, and the operator standing



Coast and Geodetic Survey Party Carried on Light Motor Cars

in the space between the tracks. Flat trays, or hand barrows, on each car are available for transporting the other instruments, tools and personal belongings of the party.

The cars are light in weight, with frames formed of steel tubing, and are capable of traveling at a good speed with their load of instruments and passengers. A small gas engine under the frame supplies the motive power, and enables the party to reach its field of operations promptly and without fatigue.

Scale on Transit Leg Fixes H. I.

An easy method of establishing the height of instrument of a transit where this is needed, as in stadia surveys, is to fix a scale on one of the tripod legs by which the length of plumb-bob string and hence the H. I. may be gaged. The procedure of placing and using the scale is as follows:

Set up the transit over the hub and measure the H. I. carefully and accurately. Have the point of the plumb-bob just touch the tack or wherever the H. I. is measured from. Swing the point of the bob to one of the legs of the transit and mark this point on the transit leg. By similar markings scratch a scale on the transit leg, using feet and tenths. Then at any time, with the point of the bob touching the tack at any set-up, the H. I. may be read directly on the leg of the transit by swinging the bob in an arc and reading the point of the bob. This will give results to the nearest hundredth, which is generally close enough.

Set Slope Stakes a Foot Outside

A deviation from the usual manner of setting slope stakes for railroad grading has been used successfully by the writer. Instead of the stake being driven slanting at the toe of the embankment or top of the cut, it is moved out one foot farther and driven down straight. Thus, each center-line stake is practically referenced by two hubs, which are much less likely to be displaced than if set at the edge of the slope. If the contractor is advised of the method of setting the stakes, it has proved easy and convenient for him to make his measurements accordingly.

Survey Data Made Available for Field Use

The engineer engaged in land surveying is often handicapped in the field by finding that he has not secured enough notes to cover the work to be done or by finding corners described by the notes at hand destroyed, together with the witness trees, and that a starting point some distance away must be sought. Again, the surveyor will often find other bearing trees than those described in the Government records; and unless he has the notes for these trees, they are worthless.

First copies of complete section notes, giving all topography, are secured for each township in which work is likely to be done. By having the topography, a tedious search for a corner is often done away with, as a reference measurement can be made from some stream or ridge. These section notes are written on specially printed blanks, each 8½ x 11 in. and ruled as shown. After being copied, all sheets are carefully checked.

To describe corners reëstablished or reset, typewritten blanks are prepared for section, quarter-section and donation-land claim corners. These are filled out whenever the surveyor, or his assistants, resets or establishes a corner.

SHEET 1

South Bndry. Between Secs. 35 - 2

Twp. 76 S. R. 5 W.

N. 89° 47' W.	Between Section 35		and Section 2	
2.00	Leave prairie. Enter Oak openings. N & S.			
7 80.	Var 14° E.			
20 10	Ravine. C. S.			
31.00	Top of ridge. N & S.			
40.00	Set Quarter Post		from which a	
	Yel. Oak.	24"	Dia. Bears. N.48°W.	132 lks.
	W. Oak	18"	Dia. Bears. S.81°W.	487 lks
57.00	Top of ridge. Begin to descend.			
69.00	Leave Oak openings, enter prairie.			
75.00	Leave hill, enter valley.			
76.30	Trail N. & S.			
80.00	Set Post Corner to Sections 2-3-34-35		from which a	
	W. Oak.	10"	Dia. Bears. S.25°W.	78 lks.
	Ash.	5"	Dia. Bears. S.81½° E.	69 lks.
	W. Oak.	12"	Dia. Bears. N 52½°W.	144 lks.
	W. Oak.	6"	Dia. Bears. N.54° E.	73 lks.

Printed Form for Section Survey Notes

From the county surveyor's records a copy is made of any descriptions of corners established. This search of records is kept uptodate, and the data are transferred to the township portfolio as soon as recorded. All reset corner sheets are filed according to township and range.

Copies of all of the donation-land claim notes for each township are secured, and these are bound along with the section and other notes in the same portfolio.

Whenever a section or a claim is subdivided, a record is made on a sheet giving character of corners and all courses and distances.

This gives the surveyor working in that township a ready reference to the work already done and many times saves a great deal of work that might be a duplicate of some already surveyed.

The newspapers are watched; and whenever descriptions are published for Torrens registration work, or other land descriptions are given, they are clipped out and pasted to blank sheets and filed in the proper township portfolio.

All of the above data for a township are bound in covers made of heavy drawing paper cut to a size 9 x 12 in. and with a back ¼ in. in width. On this cover, at the top, are printed in large letters the township and range numbers.

In practically all of the Western States, small lithographs of each township, about 6 in. square, can be obtained, and one for the proper township and range is cut down to a minimum size and pasted on the portfolio cover below the title. This plat shows the streams, sections and donation-land claims and acts as a key map for the surveyor.

To facilitate the work of securing a meridian, either by means of a solar instrument or by a direct observation, the latitude of each tier of sections in the township is figured and written on the right-hand side of the cover map, each latitude opposite the section line for which it was computed. The longitude for the nearest 10′ is also shown in its correct position on the plat.

A portfolio of the size described can be easily folded in the middle and held with two rubber bands, so as to be carried in the surveyor's pocket.

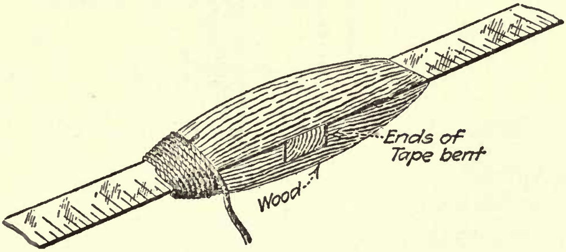
By having with him the portfolio of notes for the township in which he is called to work, the surveyor has as complete a record as it is possible to have to enable him to reset or establish corners. He also has other data of work done that will be of great value. With these notes he can go from one job to another in the same township without first having to send or go to the office for further notes.

If surveyors in the same locality could be induced to exchange notes of surveys, all data on reset corners or subdivision work could be kept up to date, and each one would have the data in shape for field reference.

Field Repair for Broken Steel Tape

From time to time there appear in the engineering magazines, methods of repairing a steel tape in the field. Most of them will slip without entirely pulling apart and are a constant source of worry. The method outlined below is guaranteed not to slip.

Heat each of the broken ends with a match, drawing the temper for about a quarter of an inch, so that it will bend without breaking. Slip the end between the blades of your knife and bend to a right angle. Then proceed to mend it by splitting a small stick and



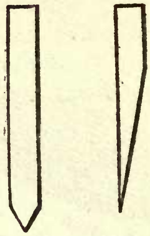
This Repair Makes Slipping Impossible

making notches in one half to take the bent ends. Wrap with a piece of twine after tapering the ends of the stick so that it will not catch in the brush. Then proceed to chain—and don't worry as to whether your tape has stretched half an inch at the splice.

Wedge-Shaped Stake Better than Straight Stake

Contractors are sometimes put to a great deal of inconvenience and are forced to lose time and make mistakes by the engineer's stakes being lost or displaced. The ordinary stake as used by the engineer is so made as to be very easily knocked out of position. This defect is due to the way in which the stake is sharpened.

The left-hand sketch gives the form of stake ordinarily used—a straight stick sharpened with a short slope from both sides. When such a stake is driven, the point is the only part firmly seated, while the body of the stake is as large just above the point as the rest of the way up, so that the stake just stands in a hole made by the point. This shape accounts for the ease with which most stakes are displaced. However, if the stake be made of the form shown at the right, it will be found to give much greater satisfaction. This stake is sharpened only on one side, but the slope extends three-fourths the length of the stake. When driven into the earth, the stake is held very much more firmly than is the other kind, because the taper is much longer and therefore the earth adheres to a greater length of the stake. It is very difficult to draw this type of stake out of the earth when once driven in. If exposed to traffic, as in the case of streets and highways, the stakes are sometimes broken off at the ground, the stake breaking before it pulls up. In this case the point is still in position and can be found and replaced.



Wrong and Right Way

A test of these two types of stakes was made on a highway on which the traffic was very heavy. The following was the result: Equal numbers of the two kinds of stakes being used, under equal exposure, 14% of the first type were entirely lost, while only 2½% of the other were lost.

Setting Grade Stakes for Bridge Approach

In grading and repaving the curved and raised approaches to the Cambria St. bridge, Philadelphia, the street surface and curb and gutter heights were first worked out by the help of a contour plan drawn to a scale of ⅛ in. to the foot, with 0.1-ft. contours. To transfer the final design to the ground the method adopted was laying out a system of points on 10-ft. squares, finding the grades of these points by interpolating between contours, and setting and marking stakes accordingly. The labor of setting these stakes was not great, and the resulting pavement surface corresponded more nearly to the predetermined one than could have been obtained by the eye or by the use of level boards.

Brass Tack in Lead Wool as Instrument Point

Contractors' engineers are often obliged to set points on finished concrete in giving lines and grades for construction work. Chalk and pencil marks are soon obliterated, chisel cuts are hard to find or easily chipped and rendered indistinct unless the concrete has thoroughly hardened, and in some cases cannot be used because they would constitute a permanent defacement. A brass tack, on the other hand, always stays bright even if set in a floor, and is easily seen.

The method which the writer has found convenient for setting such tacks is to drill, preferably when the concrete is one or two days old, a small hole an inch or more into the surface. This hole is then packed full of lead wool, into which a large brass tack with a small head is driven. Such points may, of course, be used either as transit points or as benchmarks in horizontal or vertical surfaces.

Draftsmen's Kinks

Mounting Blueprints on Muslin

Maps and plans on paper frequently fail by tearing or wearing through due to hard usage. Sensitized cloth has been employed more or less successfully, but it has its disadvantages, due to the fact that the cloth is generally of poor quality and tears easily. Furthermore, if allowed to stand for some time before being used, the sensitizing solution causes the cloth to rot. A much better and not too difficult method is to mount the paper print upon cloth. Large wall maps hang better and are much less liable to be harmed when mounted in this way than when left unmounted.

The print should be made upon "medium" weight paper unless an extra-strong sheet is desired. While the printing is going on, a helper can prepare the cloth backing. Unbleached muslin that sells at about 10c. per yard is ordinarily used. Select a smooth board, larger than the size of the print to be mounted, and clean it thoroughly. A drafting board or the top of a drafting table is excellent for this purpose—provided it is not cedar, for cedar will stain the prints. Fasten the cloth on this board with 4-oz. carpet tacks spaced about 2 in. apart, and driven only partially home so that they may be easily pulled.

Tack one edge of the cloth down, stretching it smooth but not too tightly, for the paper contracts on drying-out and will crack if there is not enough "give" to the cloth. Follow around the edge of the cloth until it is completely tacked down. It should now present a smooth surface and is ready for the mount. If many prints are to be mounted, it may be an advantage to set several boards, end to end, and tack the cloth over their entire length. In this manner considerable cloth can be saved.

After washing the prints they should be taken from the final bath and the excess water blotted from both sides with a dry towel or cloth. If the print has been made some time previously and is dry, immerse it in water for two or three minutes—or until it is thoroughly wet—then remove it and proceed as above. Lay the print carefully down on a clean table top or board and apply a thin but even coating of paste, making sure that the edges and corners have received their share. The paste should be a fresh, stiff corn-starch paste or fresh wall-paper paste. Glue or library paste is unsatisfactory and should not be used.

Pick the paper up carefully and while one man holds an edge above the cloth, the other, on the opposite side of the table, should take the lowered edge and paste it down—using a stiff kalsomine or large, flat paint brush. Brush the paper down, working *away* from the body with short strokes, the helper slowly lowering his end. In this manner the brush will drive out all air bubbles and make a uniformly smooth job. After the paper is brushed fast, take a stiff clothes brush and gently pat the edges down, thus insuring a perfect contact at the vulnerable point.

The print should dry slowly in an even, moderate temperature for at least 36 hours. The print can then be trimmed. If a Van Dyke print, corrections, if any, should be applied at this time, using ordinary black drawing ink.

Ruling with Common Ink Saves Time

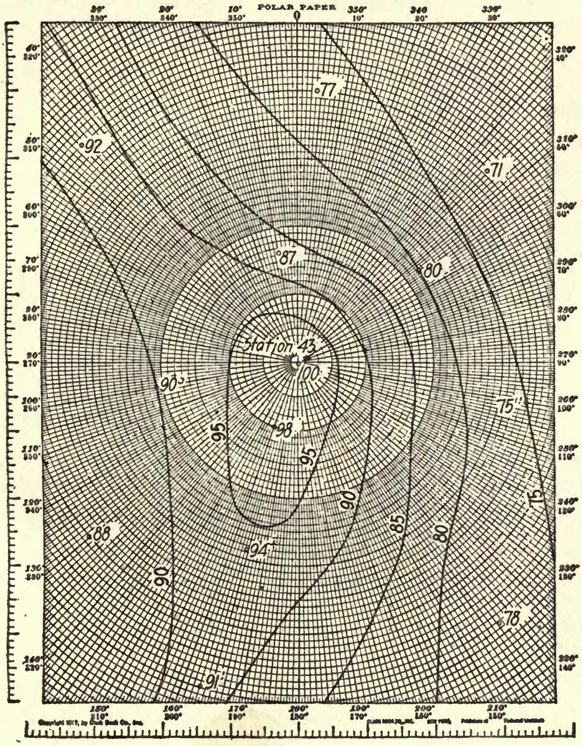
In making scale sketches on desk designing sheets for direct tracing by the draftsman, one engineer finds it a great convenience to use ordinary, in place of india, ink. This requires a german-silver ruling-pen, such as is made for bookkeepers' use. A time saving results from the fact that when the pen is laid aside with its ink filling it will not dry out, but will be ready for instant use even after a quarter or half an hour.

Drawing the sketches in ink, rather than pencil, is far easier for the tracer as well as being safer against errors in tracing. The method applies to a great many parts or objects of such simple character (or to be shown so generally) that no fuller detailing is needed than the designer's sketch contains. However, lines as fine as may be desired may be drawn.

Reducing the Cost of Plotting Stadia Notes

By plotting stadia notes on separate sheets such as are shown in the accompanying sketch and tracing the finished map from these sheets, the cost of plotting stadia notes has been materially reduced and the speed almost doubled. Plotting topography by this method becomes independent of drafting-room equipments, a lead pencil being the only tool required.

The ordinary method of procedure is to sketch the topography in heavy pencil lines and either paste the sheets together for the draftsman or send them to him separately. The sheets are placed under the tracing cloth, and the finished tracing is made directly from them. The paper used for ordinary work is 8½ x 11 in. in size.

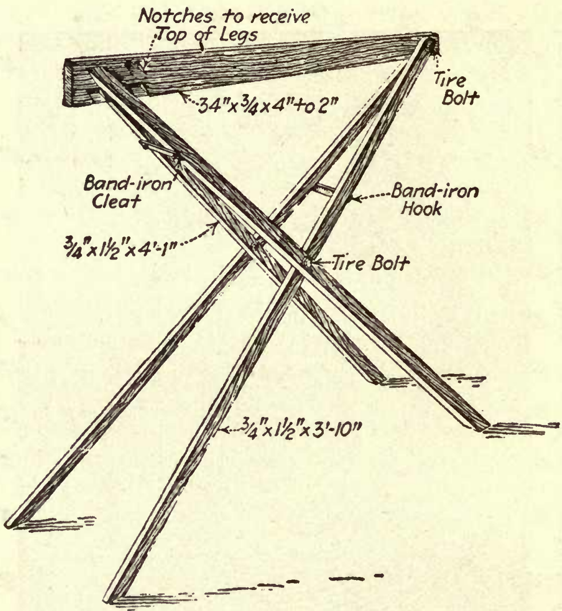


Speeds Up Interpolation—Increases Accuracy

Using a scale of 100 ft. to the inch, a length of 1000 ft. and a width of 600 ft. of topography may be plotted on each sheet. Topography may be plotted by surveyors on rainy days, either in the field or in the office, several men working independently on separate parts of the notes. It is remarkable how much the use of a graduated paper speeds up the interpolation of contours and increases the accuracy of scaling.

Folding Drawing Trestle

A drawing-table trestle which will take up a space only 4 in. square and 4 ft. long when stored, would prove a great convenience to many engineers who do not need a drawing table continually, or whose work sometimes requires one where ordinarily there would



Adjustment for Height and Slope of Board Easily Made

not be proper facilities. The construction illustrated in the accompanying drawing has been used for the past two years and has proven to be convenient, rigid, light and capable of being easily transported and stored in a small space.

The following is a bill of necessary materials:

2—¾ x 1½-in. hardwood strips, 4 ft. 1 in. long, front legs.
2—¾ x 1½-in. hardwood strips, 3 ft. 10 in. long, back legs.
1—¾ x 4-in. hardwood board, 34 in. long, top piece.
6—1-in. shothead screws.
2—2-in. tire-bolts and washers.
1—2½-in. tire-bolt and washer.
1—¾-in. band-iron strip, 7 in. long, drilled for screws on 6-in. centers and one hole cut out to serve as a hook.

1—¾-in. band-iron strip, 4 in. long, drilled for screws on 3½-in. centers.

The method of assembling is perhaps sufficiently illustrated in the drawing. By placing the top ends of the longer legs in the different notches, which must be gained in the top piece, the top of the trestle can be made either level or sloping, and the height adjusted from 34 in. to 42 in.

How To Waterproof Drawings

A. Give the drawing several light coats of white shellac, dissolved in grain alcohol, letting each coat dry before the next is applied. Orange shellac and even wood alcohol may be used; but the "white" or bleached shellac is preferable and wood alcohol is objectionable because of its injurious effect on the eyes.

B. Give the drawings several light coats of "Zapan" varnish, which is made of scrap trimmings of clear sheet celluloid dissolved in acetone and is produced by several Eastern chemical factories and firms manufacturing celluloid articles.

C. When a heavier protective covering is desired than A or B will provide, the drawing may be made wet with the thin celluloid varnish and pressed down evenly on a sheet of thin sheet celluloid, then allowed to dry. This process gives a beautiful clear mounting with 0.01 in. of celluloid on the face.

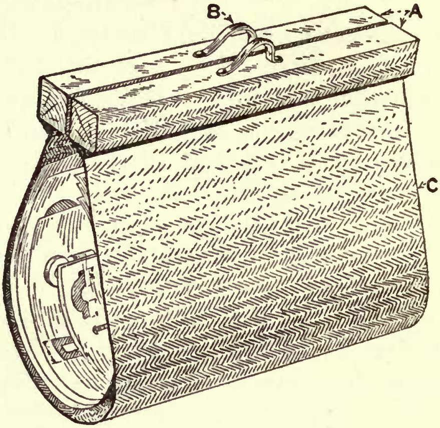
D. Drawings may be made waterproof with melted paraffin wax, which is applied with a flat bristle brush. The drawing is then put between two sheets of blotting paper, and a hot sad-iron is passed over the upper blotter, thus causing the paraffin to be distributed more evenly and the surplus to be absorbed by the blotting paper. The blotters must be removed before they cool. If the wax is thick and white over any part of the drawing or print, sponge it off with benzine.

E. Drawings may be paraffined by dissolving the paraffin wax in benzine and then thoroughly painting the drawing with this liquid or passing the drawing through a bath and hanging it up to dry.

Some of the solvents mentioned are very inflammable and even explosive, so all open lights should be kept away from them. Sometimes they affect certain people injuriously; accordingly, such work should be done only in a well-ventilated room, with a fan to keep fresh air moving over the work.

Make This to Carry Your Drawings

It is customary for drafting rooms to place their drawings, either every night or once a week, in a vault for safe keeping. The device shown in the illustration has proved satisfactory for carrying the drawings. It is easy to make, two pieces of white pine *A*, 37 x $1\frac{1}{4}$ x $\frac{3}{4}$ in., two black japanned door pulls *B* and one piece of unbleached cloth *C*, 37 x 30 in., being fastened together in the manner



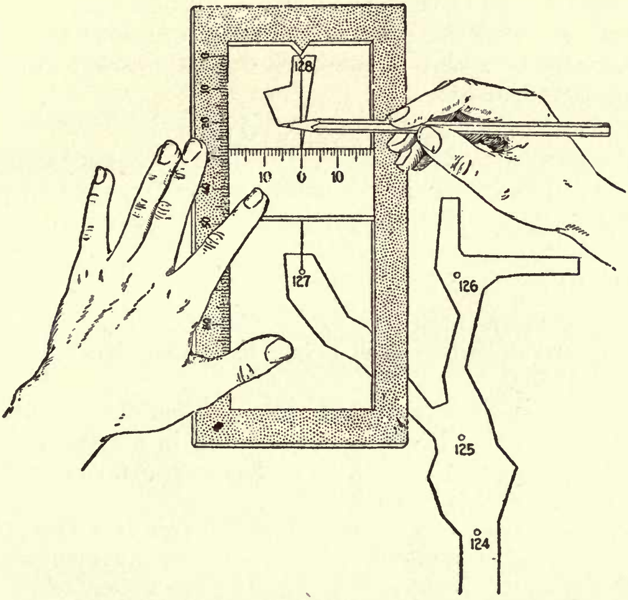
A Convenience—and Takes Up No Room

shown. If desired, a small hook and eye may be attached at each end of the wood crosspieces to hold them together and prevent the loss of drawings when the carry-all is laid down.

Plot Offsets with Frame and Sliding Piece

A device for mapping survey notes, consisting of a fixed frame for longitudinal measurements and a sliding scale for offset distances, is shown in the accompanying sketch. The rectangular frame is made of $\frac{1}{8}$-in. sheet iron. The scale along the left-hand edge can be stamped on or glued on. The sliding scale can be readily made from an old celluloid triangle. To orient the scales, the center point at the top of the hollow rectangle, which is opposite the zero of the longitudinal scale, is set over one transit point and the zero of the sliding scale over the other. The edge of the sliding scale will then always be at right angles to the base line.

It may be seen that any survey made by pluses and right-angle offsets from a base line, such as railroad station-map surveys, can be readily plotted with the device. It might be convenient to provide



Pluses and Offsets Easily Plotted by This Device

four scales by starting one from each of the four corners of the steel frame, and making two sliding pieces with a scale on each face. Both a 50-ft. and a 100-ft. scale would be used frequently.

Keeping Tab on Revised Drawings

In supervising a large concrete building job at some distance from the main office where the detail plans are made, there is ever present a danger that the latest plans may not be used by the field superintendent and the construction gang. The structural plans for a concrete building are seldom completed when bids are called for, the usual practice being to have the footing design and column schedule completed at the time so that the material can be ordered and work started without delay after awarding the contract. The detailing of the superstructure is usually carried on slightly ahead of the construction work, necessitating the issuance of several progress prints of the same plan.

It has been found worth while to issue a memorandum at the end of each week, giving the date of the latest print of each plan issued. These memo's are typewritten on standard specification-size sheets. Blueprints are made from them and are sent to the superintendent and contractors, who post them in the various field and main offices. Blueprints are used since they are more conspicuous and more apt to be regarded as a part of the plans than are carbon copies. The following form is used:

PLAN MEMORANDUM

Date............

Building for "A. B. Co." City....................

Post in a Conspicuous Place.

The latest prints of plans to be used are dated (with rubber stamp) as follows:

Sheet No......... Description.......... Date........

These memoranda are sent out on Saturday of each week, except when only one or two revised prints have been sent out since the last memorandum.

Each time a sheet is revised or some new feature is added, a note (with date made) is placed on the tracing in a space provided in the title of the sheet. In addition to this each print is marked with rubber stamps, as shown herewith.

The upper stamp calls attention to the fact that the print contains some revision or addition not shown on previous prints, and by referring to the revision list (in title) the extent of the change

REVISED PRINT
Destroy all prints
previously sent you

THIS PRINT MADE
Dec. 20 1917

Prints Marked with These Two Stamps
Upper stamp is 3¼ x 1 in.; lower is 2⅛ x ⅜ in.

can be found at once. If the print bears a later date than the one noted for this sheet on the memorandum sheet posted in the field office, the memo is revised by the superintendent to show the date of the latest print. In this way a careful record of the latest prints is kept, and anyone not familiar with all the details of the work can quickly find, by referring to the memorandum sheet, which prints should be used for construction work, and thus costly errors due to use of superseded and void plans are avoided.

Simple and Effective Methods for Filing Engineering Data

Lantern Slides Should Be Indexed and Filed

Perhaps the most customary method of filing lantern slides is in the wooden boxes which are on the market for that purpose. These are of varying capacities, containing from 50 to 200 slides. Each slide has its individual compartment formed by cardboard partitions inserted in grooves in the sides of the box. When the hinged cover is raised the rim of the long way of the box is seen to be divided off by the indentations made by the grooves. Each division marks a slide compartment, and it is convenient to number these divisions on the front rim with small india-ink figures to correspond with the numbers of the slides. On either end of the exterior of the box the inclusive numbers should be indicated. As the slides are numbered in the order of their accession no duplication occurs, and the boxes may be arranged uniformly and neatly in numerical sequence.

Each slide when received is numbered in india ink upon the thumbspot. An indelible ink is especially necessary for this since the thumbspot marks the position for the operator's thumb when he inserts the slide in the lantern, and ordinary ink would smut. Close beside the thumbspot there should be another small sticker which is left blank so that those slides selected for a lecture may be lightly numbered in pencil to insure their temporary sequence. On a narrow strip pasted across one end of the slide the brief title should be written.

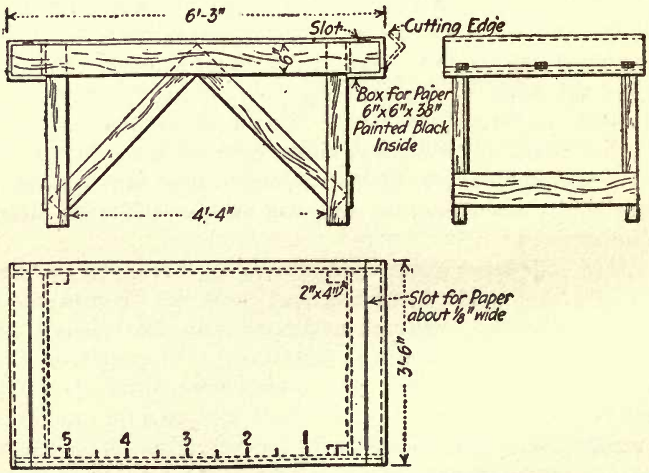
To avoid misplaced slides they should be arranged so that they face the left-hand end of the box and have the thumbspots at the top, thus facilitating ready detection of any discrepancy between a slide number and that of its compartment. Similarly, in the traveling case, this arrangement is a convenience since it enables the operator to seize the slide with its face toward him and by a turn of the wrist to invert it in readiness for insertion in the lantern.

As received the slides are listed under the headings Slide Number, Title, Owner, Date and Origin, on lettersize sheets secured between cardboard covers by brass binding pins. Following this accession list and separated from it by a colored sheet is the place or subject list. To each place of which there are descriptive slides a page is devoted upon which the numbers and titles are listed. For theoretical features, diagrams, tabulations, etc., a sheet headed Miscellaneous is provided, from which, however, any of the items may be segregated upon separate subject sheets when desirable. These place and subject sheets are assembled in alphabetical sequence.

A heavy manila envelope, say 9 x 5 in., pasted on the inside of the back cover, affords an opportunity for the filing of lists of slides temporarily withdrawn from the file. While these lists may be mere memoranda to be destroyed when the slides have been checked off as returned, it is preferable to typewrite them in permanent form upon sheets headed with the name of the borrower, the title of the talk, the place, date, etc.—since such lists have a suggestive value in the preparation of further illustrated talks. Before the slides are returned to their compartments the pencil numbers added by the borrower should be transferred to the loan list, to show the sequence in which the slides were used, and then erased from the slides.

Blueprint Table has Several Functions

The table shown in the sketch combines the functions of the storage can, the scissors and the yardstick. The roll of paper is



Blueprint Table Saves Time and Paper

stored in the box at the end and pulled out through the slot, measured with the foot marks and torn off on the cutting edge. Less than ½ in. of paper is spoiled, and this only when the strip is left exposed for a considerable length of time. At least this much is ordinarily wasted by excess cutting. The left-hand box is used for odd sheets of paper, but may be slotted and used for a different grade of paper.

Pamphlets Indexed and Filed by Simple System

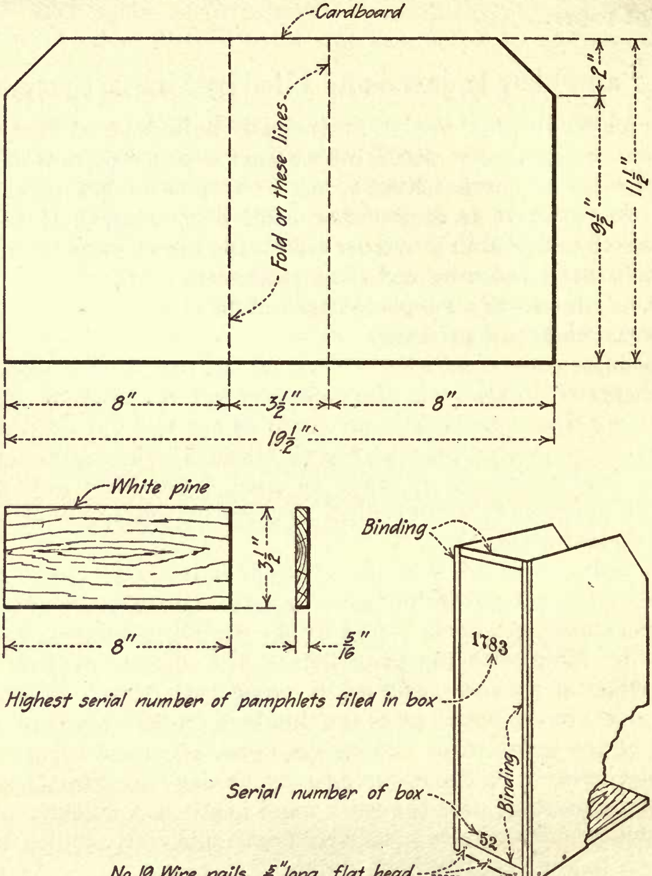
Pamphlets in great variety, principally bulletins and reports, are available in constantly increasing number and comprise a very important class of current literature. The value of the information which they contain is, however, considerably lessened if they are not indexed and filed in a manner which facilitates easy reference to their contents. Indexing and filing pamphlets by the following plan has been found to be a simple matter and to give satisfactory results as to convenience of reference.

As soon as convenient after receiving, the pamphlet is read, or at least inspected to ascertain the character and scope of its contents. As this is being done such index cards as are thought desirable are written. For this purpose a very thin 3-in. x 5-in. card ruled horizontally and made up in pads is used. For this and general notebook purposes it is convenient to carry a number of these cards in a loose-leaf notebook.

The index cards are then placed together in the pamphlet until it proves convenient to assign serial numbers to the pamphlets for filing purposes. A simple record of the pamphlet numbers assigned is kept by filing with the pamphlets a 6-in. x 9-in. card on which the last serial number assigned is noted each time. It has been found most convenient to place the numbers on the upper right-hand corner of the index cards and on the upper left-hand corner of the pamphlet cover. This numbering may be done by hand, though a numbering machine does the work more neatly and quickly. A very satisfactory substitute is a rubberstamp numberer, similar in construction to the familiar band dater.

The pamphlets are then filed in the order of their serial numbers from left to right on shelves or in bookcases. A decidedly neater appearance is given the collection when filed in pamphlet boxes. It will be found a simple matter to make up these boxes as needed after the construction indicated in the illustration. Where heavy cardboard is used, the bending is facilitated by making a very light knife cut on the fold lines. A neat appearance, as well as a stronger box, results when the exposed edges are bound with gummed cloth tape or the gummed paper strips used in binding lantern slides.

Each pamphlet box should carry a serial number as well as a number corresponding to the highest serial number of the pamphlets that are filed in the box.



Filing Box Is Easily Made

The filing of pamphlets by arbitrary serial numbers is far more simple, elastic and generally satisfactory than any attempt to classify or group these publications according to their subject matter. And any system of indexing, to be satisfactory, demands the personal attention of the person who is to make use of it, as the average office help cannot be expected to do indexing of this sort with any satisfactory degree of intelligence.

Index of Details for a Structural Office

Well executed and consistent plans are the prime indication of a good design in all classes of structures; especially in building work, which involves a great many different types for the great variety of uses. This makes standardization of details and design somewhat more difficult than for the superstructures of highway and railroad bridges, but unless standardization is kept in mind constantly, the cost of making the design is quite likely to be so high as to show little profit; and at the same time the resulting structure may be more costly to the owner than if the reverse were true.

A large structural-engineering office—one employing a large force of draftsmen and designers, and carrying on work simultaneously on several large buildings—must of necessity have a good set of office standards for the guidance of the men and as an aid to the chief draftsman or engineer in obtaining uniform practice on all jobs of the same type, without necessitating his spending the greater part of his time giving instructions and personal supervision to each and every man or squad.

The office standards for concrete building design should include tables and diagrams for the design of reinforced-concrete slabs and beams (such as values of $K = \frac{M}{bd^2}$) for various combinations of unit stresses; areas and weights of steel bars; data on web reinforcement of beams; reinforcement of spandrel girders; diagrams and tables for the design and detail of reinforced-concrete columns and footings and for steel columns incased in concrete; tables and details showing amount and method of reinforcing concrete stairs, and standard sheets showing the arrangement of lettering, dimensions, details, etc., on the floor plans. For steel building design the standards may include properties of various types of columns; connection details; bracket details; cast-iron bases; typical details of spandrel beams, crane girders, steel stairs, steel stacks, tank floors, towers, etc.

In order that original and special details developed—which would not ordinarily be indexed in the general job file or included in the standards—may be readily found, a card index of various details of completed designs in the office files, which are likely to be used on other work or referred to at various times, should be maintained. With such a file a new man in the organization can at once acquaint himself with methods of detailing certain portions of a standard or special building without a lengthy explanation on the part of the chief draftsman, thus saving much valuable time and increasing materially the speed with which the plans can be completed.

Filing Catalogs and Pocket Maps

Some of the material to be filed in an engineering library, particularly trade catalogs and folded pocket maps, is so diversified in size and shape that it is hard to handle. Thus, while it has come to be generally conceded that trade catalogs ought to be unified as to dimensions, and while this would be of advantage not only to the possible purchaser but also to the manufacturer, the catalogs continue to vary from the flimsy leaflet to the substantially bound volume. Yet, as the engineer uses them in making estimates of cost, in selecting equipment, and in other ways, he must have them readily available and well indexed.

The general indexing schedule in use in one library is a form of the decimal system, by which the books and data are assembled under various classifications according to subject matter. This modified Dewey system was found to be too detailed for application to the trade catalogs, and it was necessary to simplify it; that is, K 6, Water Works Distribution System, including in its subdivisions the subjects of pipes, valves, distributing reservoirs, conduits, meters, etc., became in the simplified schedule, K 6, Water Works Pipes and Valves; while K 6.5, Meters, became more comprehensive and included Measuring Devices for Water.

Within each classification it was decided to maintain an alphabetical sequence of the catalogs according to the names of the firms issuing them. To do this an exceedingly flexible filing device was necessary, since it was planned to place the material without regard to size and shape and without segregating the bound volumes. Pamphlet boxes would have meant considerable waste space, and vertical files either the segregation of the bound volumes or an unwarranted expenditure for filing units. Heavy manila envelopes were also considered for the filing of the leaflets and pamphlets, but were found undesirable both because they were incommodious, and because when the envelopes were stacked the exposed ends offered on surface for indexing.

It was decided to use a pasteboard receptacle open at the top, containing cardboard folders with tabs, such as are used for filing correspondence. The containers come in two widths, 1 in. and 1½ in., and are 12 in. long—just the depth of the open shelves upon which the catalogs were to be stacked. The exposed end of the unifile is curved and is covered with heavy brown paper. Upon this a sticker, bearing the classification number, was placed. Except in those instances where a whole container was devoted to the catalogs of a single firm, the indicating of the contents upon the end was avoided, so that as new material was added the cardboard folders could be shifted. On the tab at the top of each folder, however, the name of the manufacturer and the classification number were placed, while on the bound volumes and the thicker of the pamphlets strips were pasted with the firm name.

In connection with this file a card index of the names of the manufacturers was maintained, with the classification number, or numbers, under which the catalogs of each firm were to be found. It has proved extremely useful to include also in this index the trade names of materials, since these so often differ from the name of the manufacturer or of the firm issuing the catalog. As the catalogs are assembled according to subject matter, a subject index has not been found necessary, but reference to an advertising index is made when doubt arises as to the manufacturer of some special material. This method has been tried out for five years, in the filing of 16 shelves of catalogs, and found satisfactory.

From the very fact that they are designed to be tucked away, the pocket maps are likely to be tossed into a desk drawer or placed in a pigeonhole and forgotten. It is wise, therefore, to have a file of them in some conspicuous place where they will be readily accessible and will not be overlooked. Like the trade catalogs the pocket maps vary in size and shape, for while some seem designed for the coat or outer pockets, very many are long and flexible and of a form suitable for the vest or trousers pockets. A simple device for maintaining a neat and uniform file of such maps is the heavy manila envelope of standard size (4½ in. by 10½ in.) with its flap removed and a cloth tape tab 1½ in. in length pasted on the closed long edge. On this tab the brief title of the map is written. The envelopes are filed on end in alphabetical sequence of the titles of the maps. The tabs are bent to one side and as they have been pasted at varying intervals on the long side of the envelopes it seldom happens that they overlap. If it should chance that a map is too long for an envelope, the latter may be slit at the top end. This file is kept in a glass-front case and stacked by means of tin rack ends. Rack ends placed behind the envelopes will keep them from slipping back on the shelf. In the general card catalog of material in the library, the maps are listed under the subject "Maps" and also under the individual titles.

Value of Carefully Kept Stadia Notes

It is especially important that some definite form of note-keeping be followed in making stadia surveys, even if they are to be platted by the one who makes the survey. There are so many classes of information to be recorded, that if the work is not done systematically, the value of the data recorded is lost through the impossibility of transferring the information contained in the notes to a scale

I.P. & T.P.	B.S.	H.I.	F.S.	Eleva.	Stadia	Distance	Total Dist. & Mag. Bear.	Remarks	Sketches
			8.1	33.3					
			4.3	37.1				Field 20' R. of XIII	Road
XIII	4.28	41.42			658 200	458	9026 S10-30W		Y. & M.V.
12			7.49	37.14	959 537	422	8568 N49-40E	Road turns L.	
			8.4	36.2	1160 520	640	S 45 E	Field	
XII	6.17	44.63			733 302	631	8146 S49-40W	on ¢ Y.&M.V.RR.	S 12-20 E
11			3.25	38.46	455 195	260	7515 N49-40E	Hub in Road	
			6.7	35.0	875 462	413	N 10 E	Low spot 200' D.	
XI	3.85	41.71			587 182	405	7255 S49-40W		On ¢ Plantation
10			4.55	37.86	666 249	417	6850 N49-40E	Hub in Road	
			10.1	32.3				(6+12)/2 Ditch 12' L. of X	
			5.3	37.1				Field 20' R. of X	
X	3.25	42.41			537 113	424	6433 S49-40W		
				39.16					

Systematic Note-Keeping Helped by This Form

map. This form must, of necessity, be adapted to the work to be done, and should, so far as practicable, conform to established forms of note-keeping. A form used in making drainage reconnaissance surveys is illustrated by the accompanying sample of notes which were recently taken in the field.

Turning points and instrument points are numbered successively —arabic figures being used for turning points, as they are usually placed on the stake by an untrained assistant, and Roman numerals for the instrument points. The turning points are available for later cross-line surveys. All instrument heights and heights of turning points are calculated in the field as well as the stadia distance. A mental calculation is made by adding one-half the observed distance to the lower stadia reading as a check on the level reading on the central cross-head. This also serves as a check on the observed distance.

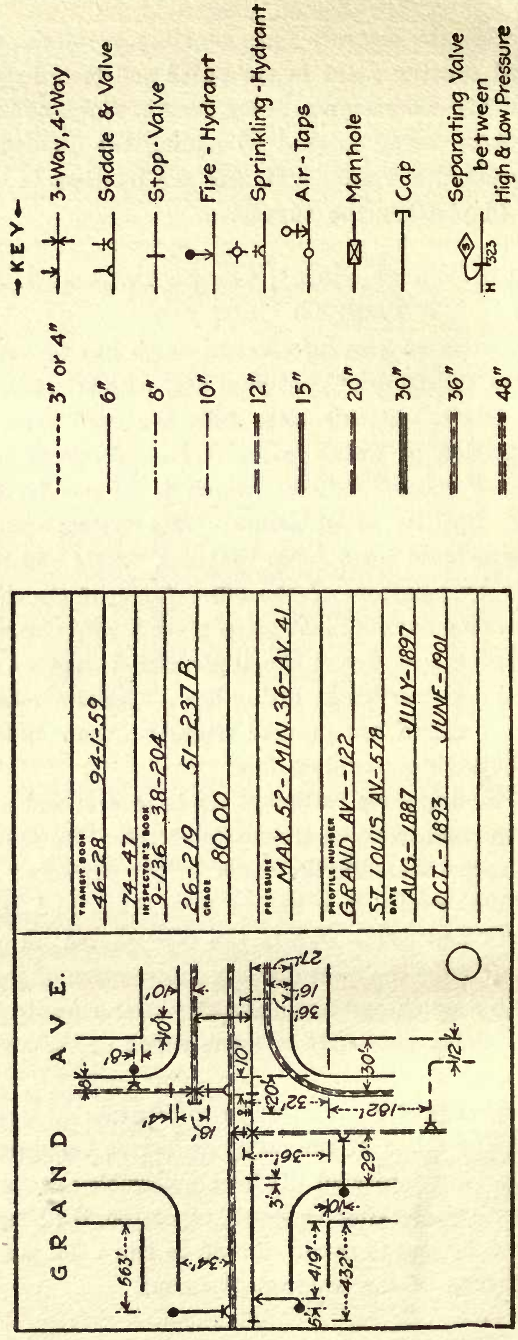
In line surveys the distance from starting point to each instrument point and turning point is computed and recorded in the distance column, this computation being done at night, or after return to the office. After being checked by adding the observed distance from starting point, the total distances are set down in ink and are of assistance in platting the survey.

Location of Water Mains, Connections and Valves Kept on Card File

Any card system of keeping records which has proven its value by twenty years and more of continual use, without radical change, is worthy of notice. In this class falls the card system for recording the location of water mains, valves, connections, fire hydrants and other special fixtures, which is in use by the Water Department of the City of St. Louis. This system comprises the use of specially printed 4 x 6 cards kept in drawers and referred to ordinarily only by members of the office force of the distribution system. The accompanying illustration gives a very clear indication of the nature of the card and the information kept on it. Each size of pipe and each particular fitting has a special symbol, and the situations of all valves are marked, showing their position with reference to the curb or building line.

The street running from bottom to top is an east and west street, and from left to right, a north and south street. The east and west streets follow each other alphabetically in the drawers; that is to say, Atlantic Ave. would come before West Ave., and all intersections with north and south streets are represented by succeeding cards which start from the most easterly intersection of the east and west street with a north and south street. Therefore, to locate any intersection it is necessary only to know which of the streets is an east and west street.

Each card is inclosed in an envelope of transparent paper, which keeps it from being soiled by the rather excessive handling to which cards of this sort are subjected. It is only possible to take the cards from the drawer by unlocking a special keeper-rod, the kkey to which is guarded carefully and is never allowed to leave the possession of the chief draftsman of the water department.



Location of All Pipes in City Readily Determined from This Card

Filing Records in a City Engineer's Office

The filing of the city's engineering records in Los Angeles is fully explained by George H. Tilton, Jr., of the City Engineer's Office. The classification is as follows:

1. Records showing location are termed maps.
2. Records showing profiles are termed profiles.
3. Records showing detail are termed plans.
4. Fieldbooks, deeds, etc., are self-explanatory.

Mr. Tilton says: "The conglomeration of sizes is sorted into lengths and a series of numbers is allotted to each length in each classification, as follows:"

1 to 249	Roll maps 12 in. wide and under.
250 to 1,999	Roll maps 12 to 18 in. wide.
2,000 to 3,999	Roll maps 18 to 24 in. wide.
4,000 to 5,499	Roll maps 24 to 36 in. wide.
5,500 to 5,999	Roll maps over 36 in. wide.
6,000 to 9,999	Flat maps of a uniform size.
10,000 to 10,249	Roll profiles 12 in. wide and under.
10,250 to 10,999	Roll profiles to 18 in. wide.
11,000 to 14,999	Roll profiles 18 to 24 in. wide.
15,000 to 19,999	Flat profiles of a uniform size.
20,000 to 20,999	Roll plans 12 in. wide and under.
21,000 to 21,999	Roll plans 18 to 30 in. wide.
22,000 to 24,999	Roll plans 30 in. wide and over.
One up for fieldbooks, deedbooks, etc.	

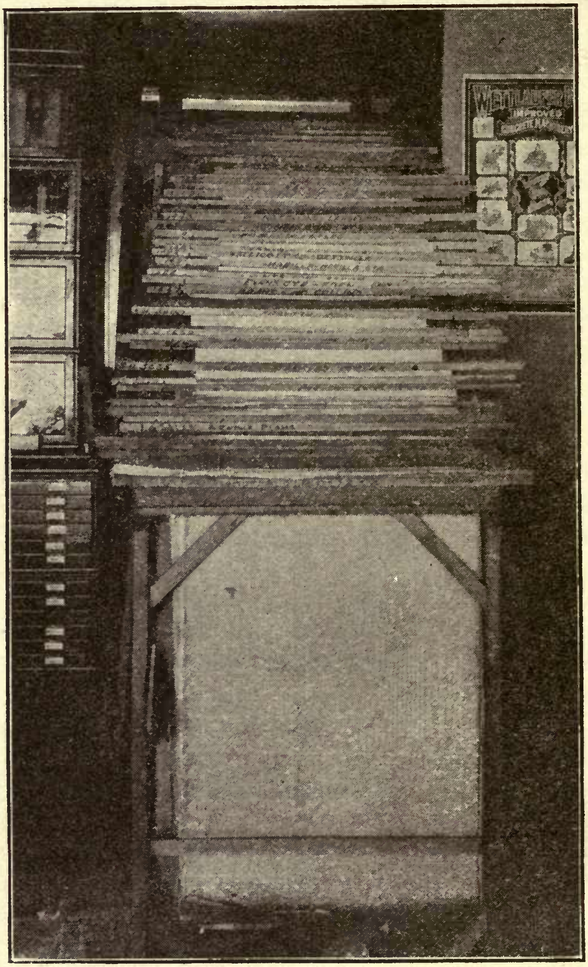
As soon as one of these series of numbers is exhautsed the alphabetical prefix is assigned and the series re-run.

The actual indexing and numbering is now ready to be done rapidly and accurately. Each record is numbered with a stamp so that all numbering is of uniform size and in the same location on the record. Each classification is listed in a "list book" and indexed both in the "division index" and "alphabetical index" so that it can be found either by name or location, one of which it is necessary to know. In the division index the records are arranged according to year made.

Sixteen years ago, when this system was inaugurated, the area of the city was 43.26 sq.mi.; today it is 337.92 sq.mi. This continued expansion has not impaired or confused the early records in any way, in fact an early record is found as quickly as a late one. To keep this system up to date and the records in place the entries services of one man have been found necessary.

Large Number of Road Plans Filed in Simple Rack

The accompanying photograph shows the method of filing blueprint road plans of a large number of townships. The scheme consists merely of mounting the blueprints of each township between two stick or lath binders and hanging each pair of binders on an inclined rack. The titles and numbers of the roads are printed in black ink on one side of the binder sticks, and just enough



Rack Inclined to Show Titles

inclination is given the rack so that the titles of all the binders are readable to one standing in front. Not only is convenience served, but the cost of the rack is negligible.