ENGINEERING NEWS AND AMERICAN RAILWAY JOURNAL.

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THE WARSHIP CONTRACTS, covering eleven armorclads, were awarded on Dec. 19 by Secretary of the Navy Long, as follows: The Cramps, the Newport News company, and the Union Iron Works, each secured one sheathed and one unsheathed cruiser of 22 knots speed, at the following prices: Newport News company, sheathed cruiser, $3,885,000; unsheathed cruiser, $3,775,000. For the same class of ships the Union Iron Works, of San Francisco, will receive $3,800,000 and $3,750,000; and the Cramps, $3,890,000 and $3,780,000 respectively. For the five battleships, the bid of the Fore River Engine Co., of Quincy, Mass., is accepted for two unsheathed battleships at $3,405,000 each; for the three sheathed battleships the lowest responsible bids are: Bath Iron Works, $3,590,000 each; the Newport News company, $3,593,000 each, and the Cramps, $3,600,000 each. The latter sum is the limit of the appropriation for these battleships; and with government equipment added all three bids exceed the sum appropriated. Other bids were ruled out as coming from concerns which practically had no existence as builders of warships of this class. The Fore River Engine Co. has built two 30-knot destroyers and is building a 17-knot protected cruiser; it is also constructing an enormous ship building plant, especially designed for warships.

OIL-FUEL FOR TORPEDO BOATS is said to be less effective than coal for producing speed, as a result of the experiments conducted lately by the U. S. Navy Department. The experiment was made on the torpedo boat "Talbot," at the New York Navy Yard, under the direction of Lieut. John S. Doddridge. While no official report has been seen, it is understood that orders have been issued to remove the fuel-oil apparatus and substitute coal. The only reason stated is that oil did not increase the steaming radius of the "Talbot."

THE MISSOURI RIVER COMMISSION may be abolished if a provision in the present River and Harbor Bill becomes a law. The general opinion seems to be that the navigation on that river is too limited to warrant a special commission; and any absolutely necessary work in bank protection, etc., can be as well done under the Secretary of War. This commission was created in 1884, and at present consists of Lieut.-Col. Amos Stickney, Major Thos. H. Handbury and Major W. L. Marshall, all of the Engineer Corps, U. S. A., and Charles O. Brodhead and C. L. Chaffee.

THE KILIA DELTA DANUBE CANAL was completed by the Russians in October last. With the Sulina delta branch of the Danube, lying wholly in Roumania, this makes a second navigable entrance to that river, and this last is in Russian territory. Of the three deltas, the Sulina, the first improved and carrying 20 ft. of water, only discharges 8% of the water of the Danube; the St. George arm, still unavailable to commerce, discharges 21%, and the Kilia branch discharges 63%. The dredging of this latter branch is said to have cost $1,750,000; but, as the Danube is the boundary for about 40 miles and the Kilia for 50 miles, Russia now has 90 miles of navigation in her own waters.

THE PROPOSED GRAVITY WATER SUPPLY for St. Louis, Mo., has been disapproved by a unanimous vote of the Board of Municipal Improvements. The grounds for this action are: Alleged inadequacy of proposed supply to meet future needs; excessive cost over filtered water from the present source; less satisfactory quality than the present source of supply, after filtration.

BIDS FOR THE CONSTRUCTION of mechanical filters at Louisville, Ky., will be received by the Louisville Water Co. on Jan. 26, 1901. Proposals may be based on specifications drawn by the company, dividing the work into 24 separate parts, as set forth in our advertising columns, and permitting bids on one or more of the parts, or filter companies may present and bid upon their own designs. Mr. Chas. R. Long is president of the company.

SEWAGE DISPOSAL AT WATERBURY, CONN., has assumed an interesting phase. Four years ago Mr. Rudolph Hering, M. Am. Soc. C. E., of New York city, suggested the alternative of chemical precipitation, followed by intermittent filtration, or of intermittent filtration, alone, on a larger but more remote tract. The city took no action, perhaps because it wished to await the results obtained by new processes of treatment. During the past summer, Mr. R. A. Cairns, M. Am. Soc. C. E., City Engineer of Waterbury, and Mr. Hering, visited some of the European sewage purification plants, and Mr. Hering has just made a second report on sewage disposal at Waterbury. Mr. Hering suggests that the smaller of the two tracts formerly proposed for intermittent filtration might be used, when needed, at as high a rate as 400,000 gallons per acre, provided the sewage was first subjected to sedimentation and to septic action; also that for a number of months in the average year the sewage might be turned into the Naugatuck River without treatment.

JAPANESE RAILWAYS, on March 31, 1900, says the "Japan Times," aggregated in length 3,635 miles, of which 832 miles were government lines. In the year ending with that date 223 miles were built, of which 64 miles were constructed by the government. The 14 private companies have a total capital of $84,610,000 gold; and with the government cost added the total amount invested in Japanese railways is $124,000,000 gold, or 250,000,000 yen. The total income from these lines, in the fiscal year ending March 31, 1900, was $19,028,580 gold, an increase of $3,237,000 over the preceding year. Of the 1900 income, $12,250,800 came from passengers, $6,319,620 from freight in income is due to lengthened line and a raise in fares.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pennsylvania R. R., near Kittanning, Pa., on Dec. 15. An empty locomotive ran into the rear end of a freight train, killing one man and injuring 13. The accident was due to the disregard of a signal by the engine-man of the locomotive.

A DRAWBRIDGE ACCIDENT was very narrowly averted in Chicago on Dec. 16. An electric car was just running on to the Randolph St. bridge when the bridge began to swing, with the result that the car was derailed before the bridge tender could stop the bridge. The front wheels of the car were on the bridge, and the car was thrown against the steel column which supports the trolley lines on the abutment. Chicago drawbridges are notoriously dangerous on account of the entire absence of gates or proper signals. Most of them have bells which are rung when the bridge is to be opened, and some have hinged signs which are displayed at the portal at the same time. The bells are not sufficient warning and the signs are of very little use. At several of the bridges a light chain is drawn across the approach roadway, but this is no protection to pedestrians, who crowd to the edge of the abutment ready to jump on the bridge as it closes.

CHICAGO'S DEFECTIVE BRIDGES and viaducts are a byword, and the latest instance of gross neglect is the death of a woman who fell through a hole in the Ogden Ave. viaduct and struck on a rail of the tracks beneath. The viaduct was a handsome and substantial structure, but the floor is in a dilapidated condition. The sidewalk planks are loose and broken and the roadways are also in bad condition. Quite recently two persons have fallen, but were both able to save themselves from dropping through. About two years ago a person injured in this way was awarded $2,000 damages. The city claims that the viaduct should be maintained in proper condition by the railways which it crosses, but apparently very little is done to enforce the requirements. It appears, however, that the Pennsylvania Co. has rebuilt the floor of the span crossing its tracks. On other viaducts the floors are in a similarly dilapidated condition.

TENEMENT-HOUSE FIRES in New York city have been reported upon by the New York Tenement House Commission. The report covers all the tenement-house fires which have occurred within a period of 2½ years, which number 7,943 altogether. It appears from a study of these statistics that of these 7,943 tenement-house fires, 7,614 were confined to the point of starting, while 329 extended through the building; that is, 4% of these fires were serious in their consequences. Of the 329 fires which extended through the building, 76, or 26%, spread by means of the light shafts; 29, or 10%, through the dumbwaiter and elevator shaft; 59 of them, or 20%, through the halls and stairs; 14, or 5%, through the light shaft combined with the halls and stairs; 70, or 24%, through the flooring or partitions; 14, or 5%, through the spaces around pipes; 16, or 5%, through windows outside the building, and 18, or 6%, in other various ways. That is, approximately speaking, one-fourth of all the fires went through the light shafts, and one-fifth through the halls and stairs, while another fourth spread by means of the partitions and floorings.

THE SUMMIT HILL COAL MINE FIRE, in the Lehigh coal regions, near Tamaqua, Pa., is said to be under control after burning 42 years; and it may be extinguished within the next two years. This fire has consumed about 35 acres of the finest coal land in the anthracite regions. Two enormous drills have honeycombed the ground to the west of the fire and the holes made have been filled with non-burning material, and it is believed that this will stop the fire.

CIVIL SERVICE EXAMINATIONS will be held by the New York City Municipal Civil Service Commission on Jan. 10, 1901, at 346 Broadway, to fill positions of shop inspector of steel, and also mill inspector of steel, for the Rapid Transit Railway. Candidates must have complete and accurate knowledge of these two branches of the work of steel inspection. The subjects of the examinations are experience, handwriting, arithmetic and technical knowledge. For further information as to the character of the examination apply to F. G. Ireland, Chief Examiner, and for applications address Lee Phillips, Secretary.

A NEW RAIL-ROLLING PROCESS, having for its object the finishing of rails at a lower temperature than is now common, is being experimented with at the Edgar Thomson Steel Works of the Carnegie Steel Co., of Pittsburg, Pa. The process is the joint invention of Mr. Julien Kennedy, M. Inst. M. E., and Mr. Thomas Morrison, General Superintendent of the steel works named. The process, as briefly described in the "Iron Trade Review," is as follows:

After the steel ingots have been rolled in the blooming mill and sheared into blooms, they are conveyed to the Siemens heating furnaces in the rail mill and allowed to remain there until they are sufficiently hot to be rolled into rails. The rail mill, as it is now equipped, consists of three trains of rolls. On the roughing train the bloom is passed forward and backward through five passes. It is then run to the intermediate or "short" rolls, where it is given five passes in the same manner. The partially rolled rail, which has been elongated until it is now about 90 ft. in length, is then run to the special cooling table, which is but a few feet to the right of the main run. This affords an interval of time between the intermediate and the finishing rolls, during which every individual rail can be brought to the same temperature, this temperature being that which has been found to produce the best results. On account of the greater amount of metal and heat contained in the head of the rail, it would be drawn in cooling into a curved shape, were it not for the precautions which have been taken. These, while very simple, are quite effective. The rail is laid on the cooling bed on its side with the head close up to the flange, or bottom, of the rail in front of it, so that the metal in the combination of two rails is about equally distributed. This allows the rails to cool gradually without causing them to become distorted. A great deal of the heat which leaves the head of the rail is absorbed in the flange of the rail adjoining it, thus keeping the temperature of the flange from being unduly lowered while the head is cooling. This is done without interfering with the rapidity or continuity of action of the mill, and it results in improving greatly the quality of the product.

THE NICARAGUAN STATE RAILWAYS and river steamers are for sale, and the New York "Herald" reports that the British consul at Greytown, representing an English syndicate, has offered $7,500,000 for them.

THE 94 STREET RAILWAY COMPANIES in Pennsylvania have been reported upon by the State Bureau of Railways. For the fiscal year ending June 30, 1900, their total income was $24,447,181; the total amount of outstanding stock was $103,176,121; and the taxes paid were $1,579,284. Of the 94 operating companies only 20 pay dividends. The total expenditures for the year were $23,976,312, as compared with $21,788,683 in 1899. The total of employes is 14,798; wages paid to them amounted to $8,043,589. In the year 538,194,532 passengers were carried, and of these 1,582 were killed by various accidents.

THE HOOK MOUNTAIN TUNNEL on the pipe line of the new water-works for Jersey City, was cut through on Dec. 14. This is the shorter of the two tunnels on the line, one of which penetrates Watchung Mountain and is 7,212 ft. long, and the other of which passes through Hook Mountain and is 1,094 ft. long. The Hook Mountain tunnel penetrates rock and when lined with brick will have an interior diameter of 8½ ft. The two gangs working from opposite portals met at about the center of the tunnel; the alinement was almost perfect. The work was done with power drills operated by compressed air and using dynamite as the explosive. The work was under the direction of Mr. Cyrus F. Sproul for the Jersey City Water Supply Co.

THE FAILURE OF A CONCRETE-STEEL GRAIN ELEVATOR AT DULUTH, MINN.

A concrete-steel grain elevator recently completed by the Peavey Grain Co., at Duluth, Minn., failed on Dec. 12 by the bursting of one of the bins while it was being tested by filling it with grain. As shown by Fig. 1, the elevator consisted of a house for the elevator machinery connected with a group of tanks for storing the grain. There are in all 15 circular bins, 33½ ft. in diameter and 104 ft. high, with 6 ft. connecting walls between them to form a number of star shaped bins as shown by the part sketch plan Fig. 2.

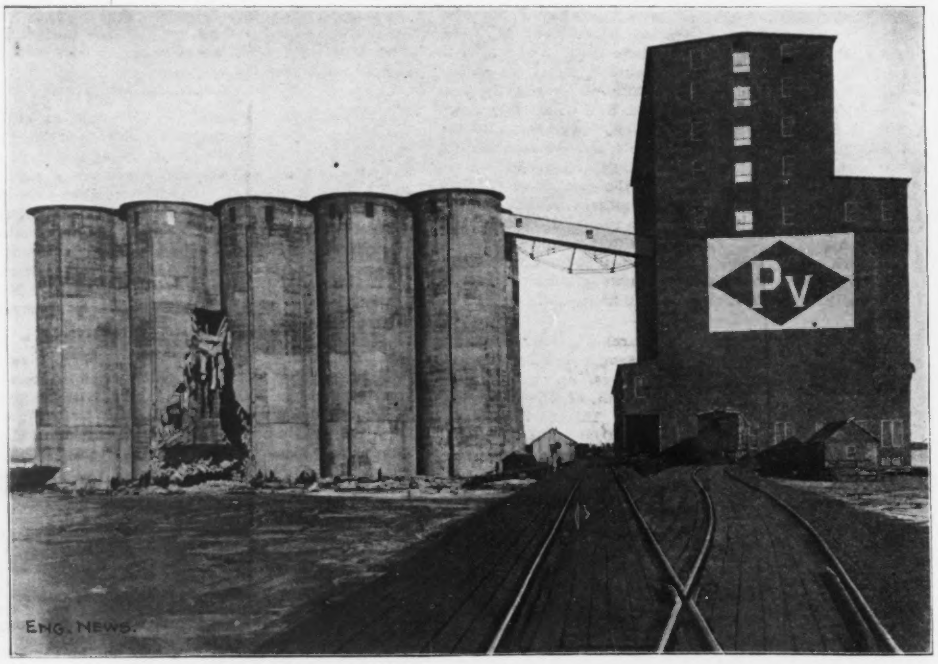

FIG. 1.—VIEW SHOWING THE BREAK IN CONCRETE STEEL ELEVATOR BINS AT DULUTH, MINN.

One of the star-shaped bins was being filled when the accident occurred, with the results clearly shown by Fig. 1. The following details of the bin construction were obtained by a member of the staff of this journal from Mr. E. Lee Heidenreich, civil engineer, of Chicago, Ill., for whom a report on the accident was made by Mr. F. W. Cappelen, M. Am. Soc. C. E., of Minneapolis, Minn.

The contract for the construction of the elevator was let to Mr. C. F. Haglin, of Minneapolis, Minn., who seems also, so far as we can find, to have designed the structure. As designed the circular bins were provided with imbedded hoops of ⅜ × 1½-in. steel bars, spaced from 12 ins. to 18 ins. apart vertically. The concrete used was composed of 1¼ parts Portland cement, 2 parts sand and 5 parts gravel. According to Mr. Cappelen's report, the upper edges of the concrete tank walls were tamped down and smoothed off at the end of each day's work, and the next day's work was started on this smooth, hard surface, thus introducing planes of separation. While this was evidently a faulty mode of procedure, it should be noted that so far as the photograph of the break, Fig. 1, shows, these planes of fracture do not appear to have played any important part in causing the failure. Besides the information collected by our representative, and given above, we have received the following letter from Mr. C. A. P. Turner, civil engineer, of Minneapolis, Minn.:

Sir: I send you herewith a brief account of the failure of the concrete steel wheat bins at Duluth. The bins were approximately 104 ft. high by 33 ft. 6 ins. in diameter for the circular bins, and 15 in number. The space between the circular bins was designed to be utilized for storage by building a connecting wall between each pair of bins 6 ft. in length, making 12 additional bins, the main sides of which are convex inward and must act as arches in resisting the thrust of the grain when the circular bins are empty. The walls run from 12 ins. in thickness at the bottom to about 9 ins. at the top, and are strengthened by horizontal bands of 1½ × ⅜-in. steel spaced 12 ins. c. to c. at the lower part of the wall. Failure occurred upon filling one of these star-shaped intermediate bins. The writer's figures indicate that the arched side of the interior bin is sufficient to withstand the thrust or pressure of the grain if given a rigid skewback, and that the cause of failure is to be found in the latter, which consists of the two 90° segments of the thin shell of the circular bins, which would evidently be subjected to bending by action of the thrust at the skewback, and would deflect outward, causing the arch to fail at the center and at the skewback. The cracks in the upper portion of the structure clearly indicate the accuracy of the above analysis. Yours truly,

C. A. P. Turner, C. E.

Minneapolis, Minn., Dec. 15, 1900.

The sketch, Fig. 2, shows by means of the dotted lines the action indicated by our correspondent's calculations. In conclusion it is only fair to point out that the concrete and embedded steel construction used in the bins which failed is radically different from the Monier system which has been employed abroad and is being promoted in this country for elevator construction.

MODERN LOCOMOTIVE DESIGN.*

By Waldo H. Marshall, M. Am. Soc. M. E.†

In the last ten years the locomotive has undergone a remarkable development. Ten years ago an eight-wheel locomotive with 18 × 24-in. cylinders and a boiler having about 22 sq. ft. of grate area and about 1,200 sq. ft. of heating surface was in quite general use for first-class passenger service; the weight on drivers seldom exceeded 65,000 lbs., and the total weight of the engine was usually within 100,000 lbs. in working order. In freight service, engines weighing between 100,000 and 120,000 lbs. on drivers were considered powerful locomotives.

To-day heavy passenger locomotives if provided with two pairs of drivers have from 85,000 to 105,000 lbs. upon them, and if of the ten-wheel type, they have from 100,000 to 135,000 lbs. upon drivers; the cylinders are 19 or 20 ins. in diameter; the heating surface is from 2,200 to 3,000 sq. ft., and the grate area is from 30 to 36 sq. ft., unless wide grates are provided for burning some special grade of coal. A freight locomotive with a weight of 150,000 lbs. on drivers is not considered a large locomotive for ordinary road work, and for mountain service and for pushing on heavy grades, engines have been built with as much as 225,000 lbs. on drivers. The tendency everywhere is towards heavier locomotives, and the reasons for building them are not difficult to find.

ECONOMY DUE TO INCREASED WEIGHT OF TRAINS.

Assuming a railroad with freight business represented by a certain number of ton-miles of revenue freight annually, it is clear that the fewer the trains required to handle it, the less will be the cost of transportation and the greater will be the average revenue tonnage per train. Revenue tonnage is, of course, much less than the total tonnage per train, as the latter includes the revenue freight, also freight for the company's use and cars in which the freight is carried.

There are two ways in which the revenue freight can be increased. One is by making it a larger percentage of the total weight of the train, and the other is by increasing the weight of the entire train. The first mentioned method involves a reduced mileage of empty cars, a heavier average load in all the cars and the construction of large capacity equipment in which the dead weight is a smaller percentage of the carrying capacity. The second method, namely, increasing the total average weight of trains, calls for a more uniform loading of engines to their maximum capacity and also engines of greater hauling power. Both phases of this second method have their influence on locomotive design, for the loading of engines to their maximum capacity searches out all the weaknesses of detail, while the demand for greater power brings up the problem involved in the construction of large engines of sizes and types best suited to the conditions peculiar to each road.

I have stated, as in the nature of an axiom, that the greater the average revenue tonnage per train, the less the cost of transportation, and yet no one not actually engaged in railroad work can hardly realize the importance of this subject to the average road. The tendency of freight rates is to steadily decrease, and this must be met by reduced cost of the service performed. Now, while economies are possible in all directions, it is a fact that nowhere in all the field of railroad expenditures is it possible to effect savings equal to those that can be obtained through the increase of revenue train load, and this is becoming so thoroughly recognized that the managements of railroad properties are in many instances being judged to-day by the showing they are making in this direction.

It is true that in the operation of a railroad there are numerous items entering into the operating expenses that are independent of the weight of the trains hauled, but, on the other hand, there are several large items that are almost inversely proportional to the average train load, and there is a third group that is influenced by it to a smaller extent. Engine and train crew wages amount to from 10 to 12% of gross earnings, and these are the items that are reduced in inverse ratio to the increase in train load. Repairs of locomotives and fuel equal 8 to 10% of gross earnings and will be reduced to some extent per unit of work done as the average train load is increased. As the total operating expenses are usually between 60 and 65% of gross earnings, there is about 15% of the entire operating expenses on which a large saving can be effected by increasing the average revenue train load, and another 10% on which a smaller but by no means inconsiderable economy will result.

This being the direction in which large economies are to be effected, it fully explains the wonderful increase in the size of locomotives witnessed in recent years, and it also points to a important work in which those responsible for the design of locomotives should have a share. If the motive power officials perform their full portion of this work, they will accomplish more in the reduction of expenses for the companies they serve than can be achieved through shop practices and routine work of their departments, important as these are.

LOCOMOTIVES FOR FREIGHT SERVICE.

When large freight power is wanted, the first question is, how heavy shall the engine be? In the majority of cases the answer to this question is found in the limits imposed by the strength of bridges and track. Even if

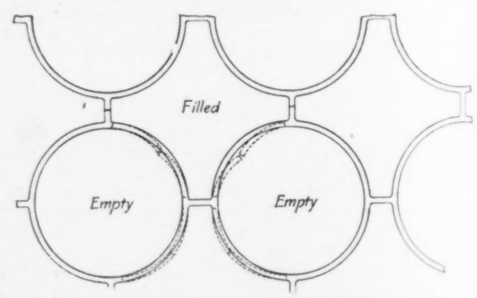

Fig. 2.—Part Sketch Plan Showing Arrangement of Bins and Probable Mode of Failure of Concrete-Steel Elevator, Duluth, Minn.

the advantages of heavier engines than the present bridges will carry are fully realized, not every road can meet the expenditures necessary for a wholesale renewal of bridges or improvement of tracks. Sometimes an engine of the maximum weight allowable under existing conditions may be needed to obtain increased revenue out of which to pay for the bridges and track that will carry a still heavier engine. But if the finances will permit it, the spirit of conservatism should not prevent the transition by a single step to the most powerful engine the road can use. Unless the physical condition of the road establishes other limits, I would say as a general proposition that the road should not only build the largest engine that could be used advantageously to-day, but if possi-

*Slightly condensed from an address before the students of Purdue University, Lafayette, Ind.

†Superintendent of Motive Power; Lake Shore & Michigan Southern Ry., Cleveland, O.

ble, should meet the conditions that will prevail in the future, say, five or ten years from to-day.

To illustrate, let us assume a low grade road whose business is largely general merchandise. Also, that an engine with 140,000 lbs. on drivers can haul all the tonnage that ordinarily can be put in 70 cars, and it is not considered practicable to haul longer trains. Five or ten years from now, the 30,000, 40,000 and 50,000 lbs. capacity cars will nearly all be out of service and with trains composed of 60,000, 80,000 and 100,000-lb. cars, and possibly containing more than 70 cars, the tonnage will require an engine weighing, say, 170,000 lbs. on drivers. Surely the engine that will meet these conditions is the one that should be built. Add to these considerations the fact that every one is endeavoring to load freight cars better than they have in the past, and it would seem a certainty that within a few years the tonnage that is now carried in an 85-car train will be brought within the length of a 65 or 70-car train. Consequently, long before the locomotive is half worn out, the conditions ought to be such that its full capacity could be utilized. If we consider the average modern locomotive as good for 20 years of service, we certainly ought not to build for today but for years in advance.

TYPES AND WHEEL LOADINGS.—The type of freight engine to be selected is next in importance to the question of weight; in fact, it really goes hand-in-hand with it. Eight-wheel engines may be considered as entirely out of the question for freight service to-day and the choice will be confined to types in which three, four or possibly five pairs of drivers are used. If the size of the engine does not warrant more than three pairs of drivers, the choice will lie betwen the mogul engine having a two-wheel leading truck and the ten wheel engine having a four-wheel leading truck. If four pairs of drivers are necessary to carry the weight there will be the same choice as far as the leading truck is concerned. In years past there have been many wordy battles over the relative merits of mogul and ten wheel engines, the most sharply contested points being those pertaining to the relative safety of the two engines and of their freedom from flange wear and damage to track. All such considerations may be safely swept aside and to-day the selection of the type should depend entirely upon the manner in which allowable weights are specified by the engineering department and upon the conditions of service. If the engineering department places a limit only upon the total weight of the engine, it is evident that the two-wheel truck will permit a greater percentage of that total weight being placed upon drivers, and if the boiler capacity can be made sufficient to furnish steam for the larger cylinders that must be provided to take care of the increased tractive weight, the mogul or consolidation engine should be the choice. On the other hand, if the limit is the total weight on the drivers and not the total weight of the engine, it is apparent that by using a four-wheel truck the total weight and also the boiler power can be increased. Where the ruling grades are heavy the mogul or consolidation engine is naturally preferred.

A few years ago it was not unusual to find the limiting weights to be those permitted on drivers instead of the total weight of the engine. As engines have become heavier, however, the limit is more frequently the total weight and it is customary for the motive power department to furnish the chief engineer a diagram of the proposed wheel bases and wheel loads from which he can determine whether the weights can be permitted. One should bear in mind that the longer the wheel base is in his proposed design, the more weight can usually be allowed. Let us assume that a proposed freight engine can weigh 170,000 lbs. in a wheel base of 25 ft., what type should be selected? If the 10-wheeled engine is chosen it will have about 40,000 lbs. on the truck and 130,000 lbs. on drivers. But an engine of the consolidation type might be adopted with four pairs of drivers having upon them 150,000 lbs. and with 20,000 lbs. upon the engine truck. The greater weight on drivers would require a larger cylinder and the necessity for ample boiler capacity must be kept in mind. It is quite possible, however, by careful designing to get sufficient boiler power and the result is an engine capable of rendering 15% greater service to the company than the 10-wheel engine. If our example had been of a larger engine, we might have had to choose between a consolidation engine, an engine with 5 pairs of drivers and a two-wheeled leading truck, or the 12-wheeled engine having four pairs of drivers and a 4-wheeled leading truck. If a sufficient percentage of the total weight of the engine could be carried on either 4 or 5 pairs of drivers, so that only a two-wheeled truck would be required, the 12-wheeled engine should not be selected. As a general proposition, a four-wheeled leading truck should not be used in any modern design of a heavy freight locomotive unless it is employed to gain increased boiler capacity through additional weight that cannot be placed upon the driving wheels. The question of boiler power is always present with the designer, and if the engine is to be one of moderate weight, it is a very serious problem. Fortunately, however, the larger the engine, the easier it is to provide the required boiler power, for the weight of the machinery and accessories does not increase in proportion to the cylinder power; thus a larger percentage of the total weight of the engine is available for the boiler.

LOCOMOTIVES FOR FAST FREIGHT SERVICE.—Another question which will arise in connection with the introduction of large power is its ability to handle fast freight trains successfully. The increase in the number of bearings and in the number and weight of moving parts makes some people skeptical regarding the performance of these large engines at speeds above 25 or 30 miles per hour, and as nearly all roads have more or less fast freight business, provision must be made for handling it satisfactorily. This cannot only be done as well with the large engine as with a smaller one, but can actually be done better, if proper care is exercised in the details of construction. The size of the driving wheels has an important bearing on this question and I am of the opinion that for all around work where grades are moderate, the wheel centers should be about 56 ins. in diameter,making the diameter outside of tires 62 or 63 ins. Until last year wheels as large as these had never been used in engines with four pairs, so it cannot be said to be general practice, but the Lehigh Valley and the Lake Shore roads had consolidation engines built in 1899 with wheels 62 ins. in diameter, which give excellent service. The larger wheel requires a larger cylinder to furnish a given tractive power, and the larger cylinder demands greater strength in the engine frames, axles, crank pins and rods, so there is a tendency towards increased weight in these parts. On the other hand, the motion of all the machinery is slower for a given speed which results in a considerable saving in maintenance and also in the reduction of machinery failures. On the whole, the advantages are very much in favor of the larger wheel.

LOCOMOTIVES FOR PASSENGER SERVICE.—What I have said regarding weights and types has concerned freight engines only. Let us turn our attention for a short time to engines for passenger service. The 8-wheel locomotive has been the standard passenger engine on American railroads for a great many years, and until recently the demand for more power was met by the production of many magnificent engines of that type. It is safe to say, however, that for the heaviest of fast passenger service, the 8-wheel type will soon be considered obsolete. The demands of the service are fast becoming such that the weight which can be placed upon two pairs of driving wheels and a 4-wheeled leading truck is not sufficient to give the boiler capacity required. But after the eight wheels engine, what next?

The answers to this question are numerous and it is too early to say whether any one type will ultimately meet with general acceptance. The 10-wheel engine, the Columbia type with two pairs of drivers and leading and trailing 2-wheel trucks, and the Atlantic type with two pair of drivers, a 4-wheel leading and 2-wheel trailing truck, are all in more or less favor. Those who believe that the amount of weight which can be placed on two pairs of drivers is sufficient for tractive purposes naturally turn to the Columbia and Atlantic types to obtain the required boiler capacity. In the Atlantic type in particular, the additional weight carried upon the trailing pair of wheels permits a great increase in the boiler capacity.

The first engines of this type that were built (except those built with Wooten or wide fireboxes for the burning of anthracite coal) had the fireboxes on the top of the frames and of the usual width, in fact the box was far enough forward to come between the main wheels. It is hard to understand why an engine of this construction was ever built. The long narrow firebox to which everyone objects was retained, when the box might have been placed entirely behind the wheels and made wider and shorter, thus obtaining any desired area of grate and all the advantages of a short box.

But if this possibility was not realized in the earlier engines of this type in which soft coal was used, it is fully appreciated now, and unquestionably an Atlantic type engine so constructed is in many respects an admirable one for passenger service. As excellent examples of this design may be cited the engines built by the Schenectady Locomotive Works for the Chicago & Northwestern Ry. These engines have 20 x 26-in. cylinders, 80-in. driving wheels, 45 sq. ft. of grate, and over 3,000 sq. ft. of heating surface. The weight on drivers is 90,000 lbs., and the total weight of engine is 168,000 lbs. The Brooks Locomotive Works have recently built several engines for the Burlington, Cedar Rapids & Northern Ry. of the same general design. The Pennsylvania R. R. has also turned out of its shops within the last 60 days an engine of this class, and the New York Central will have engines quite similar to those of the Northwestern running next January.

SIX-DRIVER ENGINES FOR HEAVY PASSENGER SERVICE.—Admirable as is this type for nearly all kinds of passenger service, I believe that ultimately the limited amount of weight for tractive purposes will lead to the adoption of some other type of engine for the heaviest of passenger service. For this work three pairs of drivers are needed. You may ask, as others have done, why it is necessary to have so much weight on drivers when it can be utilized to the utmost only in getting away from stations, the mean pressure on the pistons being too small at high speeds to require great tractive weight. The reasons are simply these: Without it the engines cannot start from 12 to 15 cars without taking slack; and to back one of these heavy engines against a passenger train until all the draft springs are compressed and then reverse it suddenly, allowing it to surge ahead, is not only destructive, to the couplers throughout the train, but is very unpleasant to passengers. Furthermore, after the train is in motion the weight on two pairs of drivers is not sufficient to utilize the full cylinder power for the first quarter of a mile from the station if the rail is slippery.

These two conditions occasionally involve serious loss of time in getting away from stations and the time so lost must be made up after the train has reached high speeds. It might be said, as many do say, that we should not haul such heavy passenger trains and that high-grade service cannot be rendered where the trains are so heavy. Such an argument, even if it is presented by those who have more or less control over the weight of the trains, should be taken with some caution. The fact is that when the grades are low the trains will not be confined to any moderate length, say eight or ten cars, nor do I believe they should where passenger travel is heavy. To place a limit of ten cars on a passenger train and to split it into two sections when eleven or twelve cars must be handled, is a piece of extravagance if passenger locomotives can be built that will handle the greater number of cars. Particularly is this true if heavy freight power has been introduced on the road and the track and bridges are capable of supporting the weight of a powerful passenger locomotive, for then it is only a question of putting enough money in the first cost of an engine to get one that will haul from twelve to fifteen cars. Then if the power of this engine is exceeded and the train must be split in two sections, each section will be a good sized passenger train in itself.

For these reasons, I believe it is necessary to have three pairs of drivers for heavy work. If correct in this, what form should the engine take? One's thought naturally turns to the 10-wheeled type, and if it were not for the question of providing sufficient grate area, I would assert without qualification that no better type of engine could be built for the service we are considering. But if the driving wheels must be more than 72 ins. in diameter, the firebox will have to go between the wheels in the usual way, and as it should not be more than 10 ft. long (on account of the difficulty of firing a longer box) the gate area is limited to about 36 sq. ft. This is less than desirable though many successful designs have no more, and some have as little as 30 sq. ft. If 72-in. wheels are adopted, the firebox can be placed over them and any desired grate area obtained. But should wheels larger than 72 ins. be required, it would appear as if some other than the common 10-wheeled type must be considered.

So convinced am I of the desirability of combining greater tractive weight with large wheels and the wide firebox that the Lake Shore is now having built two passenger engines in which it is believed this will be done successfully. These engines will have three pairs of driving wheels 80 ins. in diameter, a 2-wheel leading truck and a 2-wheel trailing truck of the English radial type. The total weight of the engine will be 175,000 lbs. of which 126,000 lbs. will be upon the drivers. The grate will be 7 ft. square (giving 49 sq. ft. of area), and the heating surface will be about 3,300 sq. ft.

THE DESIGN OF LOCOMOTIVE DETAILS.—While we will always have to force a locomotive boiler much beyond anything dreamed of in stationary practice, it certainly behooves us to obtain all the boiler capacity possible in any design of locomotive. Some years ago attempts were made to establish ratios between grate areas, heating surfaces and cylinder capacities, but now there is only one common-sense rule and that is to make the boiler as large as you can.

The weight of the machinery should receive close attention for several reasons: First. The lighter it can be made the less destructive it is to itself. Second. A reduction in the weight of all the machinery below the springs will reduce the effect upon the tracks. Third. The less the weight of the machinery, the more weight is available for the boiler. The weight which bears directly upon the track, without the intervention of springs is a considerable portion of the total engine, and at high speed the effect of this weight upon the track is certainly much more severe than equal weight placed above the springs, hence every pound that can be taken out of this portion of the engine represents some saving in track maintenance. The saving may not be great, but it is worth considering. The chief reason, however, for keeping the weight of machinery down to the minimum is the great advantage that arises in being able to put the weight so saved into the boiler, and it is needed in the latter. Those who are familiar with the daily operation of locomotives, know that in the majority of cases, the failure to "get there," if I may use the expression, can be traced directly or indirectly to the heavy demand made upon the boiler.

The locomotive of some years ago was made almost wholly of cast iron and wrought iron, and I am sorry to say that I have seen some recent engines of which the same thing can be said. The modern engine should be largely of steel. Pressed steel and cast steel permit of a large reduction in the weight of many details formerly made of cast iron and even when used to replace wrought iron, the saving is considerable. As an indication of the extent to which high-grade materials will enter into the construction of the modern engine, I will give you some figures from the design of a large passenger engine weighing about 175,000 lbs. and having three pairs of 80-in. drivers. Some of the small details have not been estimated, and others I have omitted from these figures because of their miscellaneous character, such, for instance, as the brass work about the engine, cab fittings, the piping, boiler lagging, boiler jackets, etc. Exclusive of these the amount of wrought iron in the engine is 16,950 lbs., cast iron, 19,550 lbs., of which 11,350 lbs. are in the cylinders, and 1,760 lbs. in the grates; cast steel, 27,660 lbs.,of which about 16,000 lbs. are in the driving and truck wheels; pressed steel, 1,650 lbs.; rolled steel plates and shapes, 3,770 lbs.; forged steel, 11,270 lbs.; tire steel, 10,500 lbs.; malleable iron, 1,300 lbs., and wood 4,100 lbs. The boiler weighs 47,850 lbs., and the water in the boiler, 22,500 lbs., making a total of 167,100 lbs.

When high-grade materials are employed, full advantage should be taken of the higher tensile strength and other superior qualities possessed by them. Unfortunately, some people are going into the use of cast steel without making any changes in the patterns that were used for cast iron. I recently saw a cast steel-cylinder head for a 20-in. cylinder that was not less than 1½ ins. thick in any place. It could have been made not more than ⅝-in. thick in the center, and ¾-in., or ⅞-in. thick at the bolt flangs and strengthened with ribs not more than ¾-in. thick in any place. On all four cylinder heads it ought to have been possible to save several hundred pounds. Even where cast steel is used intelligently, designers have not always reduced the weight as much as practicable. A recent case came to my attention in which the drawings of the driving wheels of a consolidation engine were revised and 1,600 lbs. of material taken out of the eight wheels. The hubs were reduced materially; considerable material was taken out of the spokes and rims, and the balances were set out as close to the rim as practicable; they were made as thick as clearance for the side rods would permit and the height of the balance was reduced to a minimum. This carried the center of gravity farther from the center of the wheel and required les weight. In such work as this, one has the satisfaction of knowing that he is not only saving weight to be used where it counts for more, but he is adding to the beauty of the engine, and is also making the machinery more accessible, an advantage of no small importance where everything is crowded as in a modern engine.

When proper attention is given to details, we find cast steel quite generally used for driving boxes, crossheads, rock shafts, rock-shaft boxes, foot plates, frame braces, equalizers and equalizer fulcrums. The material is also used occasionally for eccentric straps, engine truck swing bolsters, driving-box saddles, reverse shaft arms, guide yokes, guide-yoke knees, cylinder heads, steam chests and steam-chest covers, etc. In fact, as already intimated, it is used in almost every place where cast iron was common a few years ago, the only exception of any moment being the cylinders and the grates. Pressed steel should be used for boiler fronts and boiler front doors, cylinder-head castings, steam-chest casings, sand box and dome casings. Some railroads favor metal cabs or a combination of metal and wood. Unless the climate is unusually destructive, wooden cabs are good enough for any one. A wooden cab was recently substituted for a design calling for part wood and part metal with a saving of 500 lbs.

Cast-iron cab brackets supporting the rear end of the running board and cab can be replaced with steel plates ¼ to 5-16-in. in thickness, and strengthened with angle iron edges with a saving of about 300 lbs. in weight. The cast-iron steam pipes in smokebox on a locomotive are usually none too heavy in the flanges, but much heavier in the body than necessary—300 lbs. was recently taken out of a set of these pipes with no disastrous results. If they had been made of malleable iron another 100 lbs. could have been saved. The sand box base, which is usually of cast iron can be made of pressed steel with a saving of about 150 lbs. On engines standing too high to permit the safety valve to be placed in the dome, it is customary to rivet a cast-iron turret on top of the boiler onto which the safety valves are screwed. The cast-iron turrets can be thrown away and the safety valves put directly into the boiler, saving 250 lbs. There is a difference of more than 1,000 lbs. in the weights of well-known boiler coverings on the market and as some of the best boiler coverings are also among the lightest, there is no need of sacrificing any weight in this direction.

Grate bars and the side frames supporting them are so heavy that the designer who must save weight looks at them with longing eyes. There does not seem to be much chance of saving weight in the grate bars themselves where the pattern is a reasonably good one, but I have seen patterns so unreasonably heavy that 1,000 to 1,500 lbs. could be saved by changes in them. Grate side frames on some recent engines have been made of pressed steel instead of cast iron and a saving of about 400 lbs. effected. The fire door is usually a heavy affair hinged to a cast-iron frame bolted to the boiler. A pressed steel door with a cast-iron liner can be hinged directly to the boiler head with a saving in weight of, say, 250 lbs.

The supports between boilers and frames usually afford some opportunity for a saving. Heavy brackets on the sides of the fireboxes having a sliding contact on supports bolted to the frames are surprisingly heavy. In a case that recently came to my notice a pair of them weighed 750 lbs., and yet they did not look excessively heavy. Heavy knees bolted to the back boiler head and bearing on the foot plate also run into weight rapidly. Among the lightest forms of supports between boilers and frames are plates of steel from ⅜ to ½, or 9-16-in. in thickness; they are secured vertically between the frames and the boiler, and they have the advantages of dispensing with all sliding or pin connected supports, the expension of the boiler simply deflecting the plates slightly.

It may seem to you that many of these items represent comparatively small savings and yet in a recent case where it was necessary for me to take three tons of weight out of a proposed consolidation freight engine, the weight of whose details had already received considerable attention, we were enabled to get all of it out of the machinery and the many small accessories of the locomotive and not one pound of it had to be taken out of the boiler. Of course, every detail has to be scrutinized carefully and many little items too small to mention here had to be taken care of, in addition to the larger ones to which I have referred.

In the design of the boiler itself, weight is often added without a sufficient return. The shape of the boiler should be carefully considered. The boiler barrel, which will provide the greatest amount of tube-heating surface with the smallest weight, is one which is smaller at the front end than at the rear; consequently, a straight boiler represents an excess of weight. The reason why the two ends of the boiler should be of different diameters will be clear on reflection. The front end can be filled with tubes up to the dry pipe. The back tube sheet, in order to contain this same number of flues, should be about as wide as the diameter of the front tube sheet, but as the back tube sheet is a part of the firebox and must have the water space around it, the shell at this place must be approximately equal to the diameter of the front end, plus the sum of the two water spaces at the sides of the back tube sheet. This will mean that the back end will be from 8 to 10 ins. greater in diameter than the front end. The barrel, which is usually made in three courses, should be straight in the first two and all of the taper put in the third sheet; but appearances, the necessity of distributing the weight on the wheels properly, and other considerations usually modify the shapes somewhat. The Belpaire and radial stay fireboxes weigh much less than the crown-bar type, and have other advantages. With these boxes the dome, of necessity, must be placed ahead of the firebox, and it is, therefore, usual to build what is known as the extended wagon-top boiler instead of the old fashioned wagon top.

The long, narrow grate placed first between the frames and later made somewhat wider and placed on top of the frames and between the driving wheels, weighs very much more for the same grate area than do the wider fireboxes that are now coming into favor. Whether the long, narrow box or the wider box is used, it is possible to save weight by reducing the diameter of the shell over the firebox from throat sheet toward the back head. Theoretically, the boiler of least weight is one with a square firebox and with the greatest diameter at the back tube sheet, with the shell reduced in diameter each way from that point.

What I have said regarding the saving of weight in machinery and other details, the use of high-grade materials, the correct proportions of boiler, etc., apply to both passenger and freight locomotives, and in these days when so much is desired of both classes, as great care is necessary in designing one as the other.

FUEL ECONOMY.—Some of the matters mentioned have more or less bearing upon the fuel economy of the engine. This feature should, of course, be kept in mind constantly for not only will money be saved in operation, but the fireman's duties will be lightened, or a greater service rendered for the effort on his part. I believe piston valves will accomplish something in this direction, some of the economy resulting from a reduction of the internal friction of engine, but most of it being accomplished through the reduction of cylinder clearance, which is possible with this valve. The valve can be made as long as the cylinder, the steam ports short and straight, and the clearance as low as 5 or 6%. Much less than this cannot be used in conjunction with the link motion. The piston valve must have internal admission if the clearance is to be reduced. This construction also has the advantage of keeping the live steam passages in the cylinders and saddle away from the outside walls so that the loss from radiation is reduced.

Internal admission reverses the direction of motion of the valve as compared with common slide-valve practice. Consequently, if no other changes are made in the valve motion, the eccentrics must be set directly opposite their present position with relation to the cranks. This involves crossed eccentric rods and a very unequal distribution of steam in the cylinders. The remedy is to do away with the rock shaft or use what is commonly called the "marine" link, in which the eyes for the eccentric rods are at the ends of instead of on the back of the link. The "marine" link requires a larger eccentric throw for a given valve travel, and it would seem as if the omission of the rock shaft is the easiest solution of the difficulty.

Compounding is also a possible means of economy of fuel, but that subject is so broad that it cannot be entered upon at this time. However, matters pertaining to economy are certain to become more and more prominent in the future, and undoubtedly scientific investigations into the sources of loss in locomotive performance will be much more common than at present.

The allowable stress in materials vary greatly in different parts of the engine, and the same is true of pressures upon bearings. On driving boxes the pressure seldom exceeds 200 lbs. per sq. in. of projected area. On the main pins this pressure may be as high as 1,600 lbs. per sq. in., and no trouble from heating or excessive work will result. The pressure upon the cross-head pins may rise to 3,000 lbs. per sq. in. The allowable stresses, as far as they can be calculated, cover almost as wide a range as do bearing pressures. The only stresses that can be calculated in locomotive frames are those due to steam pressure on the piston, and these may be as low as 2,000 to 3,000 lbs. per sq. in. in some portions of the frames, and yet the latter be none too strong to stand the other stresses to which they are subjected; in fact, locomotive frames can be correctly proportioned only through experience with earlier designs. In the main rod strap the fiber stresses should not exceed 5,000 to 8,000 lbs., whereas in the main rod body the maximum stresses can go to 10,000 lbs. per sq. in.; and so throughout the entire locomotive the limits to calculative stresses has been found by actual experience. No greater mistake can be made in the design of details than to materially exceed the stresses that have been found to be satisfactory in service. I have in mind the case of a number of locomotives built some years ago in which the main crank pins were entirely too small in diameter. They ran for several years without any fractures, and then in one week five main pins were broken on 11 engines. Calculation showed that the maximum fiber stresses were more than 25,000 lbs. per sq. in. One ought to make it an inexorable rule not to increase fiber stresses or decrease bearing areas in essential parts beyond the safe limits established by experience.

A handsome locomotive hauling at high speed and apparently with so much ease a long passenger train, or dragging with slower motions many hundreds of tons of freight, is a sign which pays the designer for all of his labor, and if we reflect upon the great work which the locomotive is doing and will yet do for mankind in the development of the resources of nations, and the extension of the bounds of civilization, we find inspiration for careful, conscientious work in the assurance that whatever can be contributed to the perfection of the locomotive is worth the best efforts of the mechanical engineer.

THE CASCADE ROCK-FILL ON THE ERIE R. R.

We illustrate in the accompanying sketch plan and elevations, and the photographic view, Figs. 1 and 2, the somewhat celebrated permeable embankment of loose rock filling located on the Erie R. R., and known to those familiar with its existence as the Cascade Rock Fill. This piece of construction has been so frequently cited as a precedent for a rock-fill dam that it is worth recording in some detail in this connection, as well as for being an unusual example of railway construction. We are indebted to Prof. Lewis M. Haupt, M. Am. Soc. C. E., for the information from which this description has been prepared.

The location of the Cascade rock-fill is on the Erie R. R., within a few miles of the famous Starucca viaduct, and 184 miles from New York city. It serves to carry the traffic across a deep and narrow gorge, which was formerly spanned by a bridge, of 275 ft. span, located at a height of 175 ft. above the bottom of the ravine. The drainage area above this crossing is about 5 square miles; but no reliable data as to the rainfall and run-off is available. The Division Road-Master, Mr. E. T. Reisler, says, however, that "The heaviest flow is from a warm rain on deep snow, with the ground frozen; and this may be equivalent to 2 ins. per hour for four hours." The pool formed is usually 10 to 20 ft. deep; and in high water the pool rises to the tunnel, Fig. 1. Mr. Reisler says that this range in water level through the entire area of the fill probably tends to decay, in dry times, and wash away in high water, any vegetable matter carried into the loose rock filling, which might block the water passages if left under a constant head. The foundation of the fill is presumably rock, with perhaps some rock detritus at the edges. Mr. Reisler also states that there has been no change in the passage of water through the fill since 1888; and that it still carries the drainage, except after heavy rains or rapid thaws. The fill was probably constructed in 1850. In 1875, the bursting of a dam further up the stream filled the tunel, or spillway, and cut the toe of the fill; but the damage was not serious, and the original fill is otherwise intact.

The sketch plan and sections, Fig. 1, show a deep pocket, about 160 ft. below grade, where the bed of the original channel turns at right angles, discharging under the railway bridge into the Susquehanna River. A wooden bridge was erected here about 1837; and instead of rebuilding it the roadmaster in charge of the line concluded to risk a loose rock-fill, believing that the loose rock would pass the drainage of the tributary basin without risk to the railway, and with slight cost for maintenance. The results proved the soundness of his judgment; the pool is almost dry at times; and at other times the water rises to the level of the spillway, located 53 ft. above the ordinary water level and runs through it, almost full. This spillway has a cross-section of 135 sq. ft.

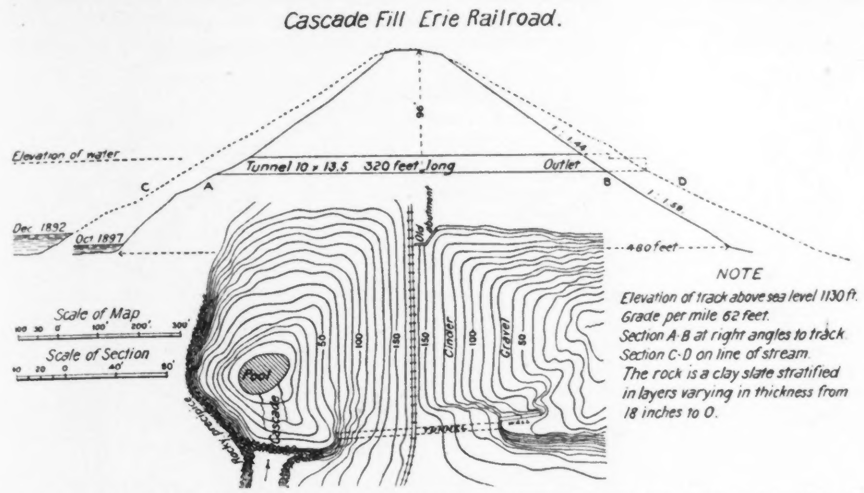

FIG. 1.—SKETCH PLAN AND SECTIONS SHOWING CONSTRUCTION OF THE CASCADE ROCK FILL ON THE ERIE R. R.

The bottom part of the fill, according to Prof. Haupt, is a slaty rock, cut from the bluffs, and it is faced with earth at the top, gravel at the middle, and with cinders near the bottom of the slope. The down-stream face slopes 1 to 1.44 for the cinder, and 1 to 1.6 for the gravel; the bottom width through the embankment is 480 ft., and the total height above the pool-level is 160 ft. The view given in Fig. 2 shows the down-stream face of the fill and the mouth of the spillway, with its guard wall. Prof. Haupt concludes that this structure is no precedent for a rock-fill dam; as it was not constructed for that purpose, and does not perform that function. As a permeable embankment, to serve as a causeway, it has fulfilled its purpose admirably for years; but it has not been "practically watertight since 1888;" nor does it "discharge through the tunnel," as has been stated, except under the conditions noted.

ROAD ADMINISTRATION IN INDIA AND THE UNITED STATES.*

By J. F. Pope, C. E.†

The greatest and most perfect system of good roads in the world, both as to construction and economical administration, is that of British India. One of the secrets of the commercial success of Great Britain is her recognition of the fact that an uninterrupted and easy access of products to market, whether internal and local or to the seaboard for exportation, means a steady trade with the least uncertainty of quantities and consequent fluctuations of prices. Therefore among her first efforts in all lands and dependencies that come under her control are the construction of good macadamized or other hard roads, both to stimulate agricultural production and to facilitate the carriage of the products to the railways.

India, including Burmah, though not quite as large as the United States, has about four times its population, and the total length of the macadamized country roads is over 200,000 miles, all efficiently drained and bridged, and every mile kept in thorough repair. The term macadam is there applied to all roads built with a hard surface, whether of stone, gravel or coarse sand. The latter is well rolled in 2-in. layers to insure a compact and hard surface. Nearly a hundred years of experience has been handed down through a succession of civil engineers, all thoroughly tested both mentally and physically before appointment, and all necessarily graduates of a civil engineering college. This has given the great Public Works Department of India (into which only such men as I have mentioned are permitted to enter) an excellent system of road making, in efficiency of construction and economy in expenditure. The general result of the 100 years' experience may be summarized as follows: (1) For all country roads a width of 18 ft. of macadamized surface is sufficient; (2) with good drainage, a thickness of 5 ins. of good road material is sufficient;* (3) the grade should not exceed 3% except under extraordinary conditions; (4) it is more economical to keep the road surface in constant repair than to put off repairs until a certain season; holes and ruts should be repaired promptly, small quantities of road material being kept for this purpose at intervals on the earth portion of the side of the road; (5) the earth portion should be 18 ft. wide, on one or both sides of the hard road, and should be kept in good condition for driving in dry weather; (6) complete renewal of the road surface should be made when it is reduced so that the wheels of heavy vehicles are likely to break through; the new surface should be at least 3½ ins. thick, and laid so as to interfere with traffic as little as possible; (7) narrow tires should be prohibited for heavy vehicles.

With regard to the administration of the roads, India is politically divided into provinces, each having its own governor, and all under the control of the governor-general. A province corresponds to a state in this country, except that the average population is about 20,000,000. A province is subdivided into what may here be termed counties and townships, though they are much larger in population and area than the same subdivisions in this country. The counties and townships are respectively under the control of a commissioner and his deputies. The Public Works Department, which is one of the great administrative departments of the general government, supplies civil engineers to the governors, who assign them to the subdivisions according to their requirements. The engineers are independent of the commissioners and deputy commissioners and are subject only to the provincial chief engineer, who resides at the capital of the province. At a stated time each year, each commissioner holds a convention with the deputies and engineers of his county, when the requirements in regard to new roads and maintenance are discussed in detail, and suitable appropriations are made, within the limits of the taxable assessment of the county. The commissioner and the county engineer form, as it were, a committee of arbitration between the conflicting claims of the individual townships, and all the proceedings of the convention are subject to the supervision and control of the governor and the chief engineer, so that full justice is meted out to all, according to the necessities of their traffic.

*Abstract of a paper prepared for the Road Improvement Convention held in Chicago, Nov. 19 to 21.

†874 W. Adams St., Chicago, Ill. Late of the Public Works Department of the Government of India.

*It is to be noted that Indian roads do not have to endure frost.—Ed.

FIG. 2.—VIEW OF DOWNSTREAM FACE OF CASCADE ROCK FILL AND OUTLET OF SPILLWAY TUNNEL.

NOTES FROM THE ENGINEERING SCHOOLS.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—A base measuring instrument which has been perfected in the Department of Civil Engineering, was recently tested by the Coast and Geodetic Survey in Washington, D. C. Satisfactory results were obtained and further tests will be made on the survey of the Lampasas Base in Texas. Professor Burton, under whose direction the apparatus has been worked out, has been invited to accompany the expedition.

PURDUE UNIVERSITY.—The Trustees are endeavoring to establish a locomotive museum, to consist of a collection of typical machines. Railway companies having machines which are to be sent to the scrap-heap are asked to first consider the advisability of having them preserved at Purdue. The University is prepared to meet transfer charges, to house and otherwise care for engines thus deposited, and to hold the same at all times subject to the order of the owner. The engine, to be desirable, must be distinctively different from others of the collection. Three engines have already been secured. One of these, the donors of which desire to remain unknown, is of the eight-wheel American type as built thirty years ago. The second engine is to be the gift of the Baltimore & Ohio Ry., and represents the "camel-back" type which has so long been in service upon that road. The third is the English engine "James Tolman," which was exhibited at the World's Fair in Chicago, and which has since been in the keeping of the Chicago, Milwaukee & St. Paul Ry. There is needed of the old class of engines one of the single-driver type, and one having inside cylinders, and, also, types of switching engines. Consolidation and mogul engines will doubtless be obtainable as time passes.

LOWELL TEXTILE SCHOOL.—Plans for the new buildings have been accepted by the trustees. It is intended to have a square of buildings about an enclosed court. The main building will be 80 × 260 ft., and will be two and three stories high. When all the buildings are completed they will cover an area of 260 × 355 ft.

CORNELL UNIVERSITY.—The mechanical engineering students have organized a society to be known as the Cornell Society of Mechanical Engineers. The membership at the start is about 60. It is intended to secure prominent engineers from various places to deliver addresses before the Society.

AN ASPHALT WAR is on in Venezuela, involving the ownership and control of the Bermudez asphalt lake, 20 miles from the Venezuelan coast. This enormous natural deposit of asphalt has been in the possession of the National Asphalt Co. for over 12 years. On Dec. 13, President Castro is said to have arbitrarily cancelled this company's concession to work the lake; and to have then awarded control over one-third of the lake to a rival syndicate. This new syndicate is claimed to have secured its rights by the payment of $40,000, and is to work under a concession granted in 1897, and then decided against by the courts in favor of the National Co. It is this decision that President Castro now reverses. Mr. Charles M. Warner, of Syracuse, N. Y., one of the syndicate referred to, claims that he has a valid title to certain asphalt deposits in Venezuela; and the present attempt of the National Co. to fight him and to induce the United States to coerce the Venezuelan government in its favor, is the work of the asphalt trust, of which he is not a member, having sold his property to Mr. Charles R. Flint, the organizer of the trust.

3,000 MILES OF RAILWAY IN JAVA are to be built in the coming year, according to a Pittsburg press item, and the same authority says that representatives of the Holland government have purchased 12,000 tons of steel rails from the Carnegie Steel Co. for this purpose. The representatives named are: Gerard Alpherts, Chief of the Technical Bureau of the Department of the Colonies, and C. W. Weys, Engineer of Water-Works in India-Netherlands. They are said to be in the United States investigating water-works machinery and railway equipment. Holland is alleged to be starting a new system of development in railways and water-works in its colonies in India and Java, involving the expenditure of a very large sum of money. The Great Northern & Western Railway, of England, is also said to have placed, through John Price, an order for 3,000 tons of steel rails with the Maryland Steel Co., and the London, Brighton & Southern Ry. is reported as having virtually closed an order with the same company for 3,000 tons of rails.

A SELF-GOVERNING IMPULSE WATER-WHEEL.

The speed regulation of an impulse water-wheel may be accomplished in two ways. The jet of water issuing from the nozzle may be varied in quantity and velocity by throttling, or the quantity of

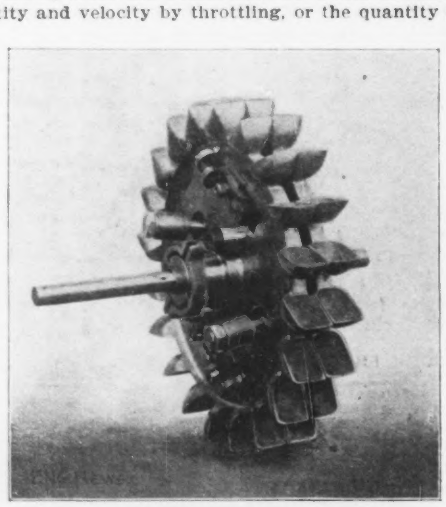

Fig. 1.—The Cassel Self-Governing Water-Wheel.

water striking the buckets of the wheel may be varied by deflecting the nozzle so that part of the stream issuing from it will miss the buckets.

The first method of governing, although extensively practiced, often causes serious difficulties, especially when dealing with water at high heads. Any sudden restriction of the stream issuing from a nozzle gives rise, firstly, to water-hammer in the pipe-line, and, secondly, to an increased velocity of the jet, which in a measure defeats the object of the throttling. Both of these difficulties may be more or less overcome by the use of air chambers and relief valves. It may be added that unless throttling is accomplished by a specially designed valve or unless the regulation is so effected that one jet after the other is completely shut off, a serious waste of power results. Throttling by a valve in the supply pipe, for example, causes loss of head by friction and eddying and this loss continues as long as the wheel runs under partial load.

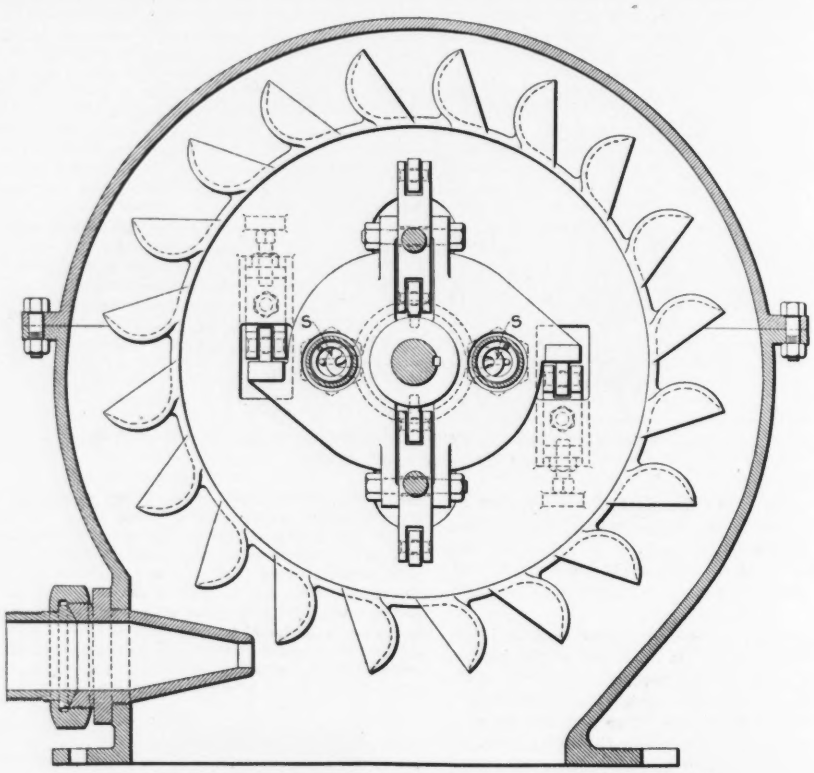

FIG. 2.—THE CASSEL WATER-WHEEL, TRANSVERSE SECTION.

Governing by diverting or deflecting the impinging stream may be done in three ways. Firstly, the nozzle may be so hinged it can be turned aside in such a way that part of the stream will miss the buckets, or, secondly, a hood may be arranged to cut off part of the stream. The third method involves the use of the special type of wheel which we are about to describe.

A perspective view of the wheel is shown in Fig. 1. The buckets are similar to those generally used on impulse wheels, except that they are split through the middle dividing wedge by a plane perpendicular to the shaft. Each half is mounted upon a separate disk, which can slide longitudinally upon the shaft. The turning moment is transmitted to the shaft by rollers running upon projections upon a central hub fastened rigidly to the shaft between the two first mentioned disks. This arrangement is shown in detail in Figs. 2, 3 and 4.

The two outside disks are pulled together by two spiral springs SS placed one on each side of the shaft. When the wheel is standing still, these springs hold the two parts of the buckets firmly together. But there are also mounted upon the middle disk two sets of fly balls or governing weights. When the wheel is running the action of these weights is to spread the halves of the wheel apart, thus allowing a part of the jet to pass through without touching the buckets. By properly adjusting the position of the weights the governor may be made as sensitive as desired. The device of having a large weight partly counterbalanced by a small one, both being so arranged that they may be shifted, admits of great delicacy and range of adjustment. The weights may be so fixed that when the wheel commences to open it will open entirely, or so that it will open only in proportion as the speed is increased.

The chief advantages of this wheel over wheels regulated by independent governors operating deflecting nozzles or hoods and throttling devices lie in its sensitiveness and quickness of action and its comparative simplicity. It is compact and self-contained and requires no mechanism outside of the wheel. As regards economy of water, however, it is of course on exactly the same footing as a wheel provided with a deflecting nozzle or hood.

Where economy of water is important a wheel may be provided with a number of nozzles, which may be opened or shut off one after another by hand to take care of variations in the load which continue for a considerable time. It may be pointed out that with any water wasting system of governing, enough water must go to waste at ordinary loads to cover any probable momentary increase in the load. For while a water-wasting governor is able to take care of any decrease in the load, it can take care of an increase only as long as the increase is within the capacity of the jet.

Where economy of water is an object, the ideal system of governing would appear to be a combination of a water-wasting with a throttling system, so arranged that with any decrease of the load the former would act quickly, to be followed slowly by the latter. For an increase in load the throttling governor should act quickly. If the throttling valve were of the central pin type, like that used at the Snoqualmie Falls plant and illustrated in our issue of Dec. 13, the water would be used at maximum efficiency at all times except during changes of load. If the above described wheel formed part of the combination the buckets would always be closed when the load was uniform and they would open only during the period of adjustment with a decrease of load.

The self-governing wheel above described is the invention of Mr. E. F. Cassel, of Seattle, Wash. His present address is care of Assi & Genez, 6 rue de Havre, Paris, France. The wheel has been patented in all the principal countries in the world, and Mr. Cassel is now seeking to introduce it commercially in Europe. We are indebted to him for the information here presented concerning it.

INSPECTING AND CLEANING AN INTERCEPTING SEWER AT COLUMBUS, O.

Some interesting sewer inspection and cleaning work is described in the last annual report of Mr. Julian Griggs, M. Am. Soc. C. E., Chief Engineer of the Department of Public Works, Columbus, O. An intercepting sewer, from 2½ to 6 ft. in diameter and 6.8 miles long, was built between June, 1889, and Aug. 22, 1892. About twenty 3 to 15-in. sewers discharge their dry weather flow into this sewer, most of the connections having been made in 1894, the last one in August of that year. The sewer parallels the Olentangy and Scioto rivers, discharging into the latter by gravity, through an inverted siphon. For a number of years past the intercepting connections have been getting badly clogged with sand, boulders, brick and rags. One of the connecting sewers, receiving gas wastes from the State Penitentiary gas works, has been the cause of much obstruction, through deposits of tar.

In August, 1899, the deposits at one point in the intercepting sewer had so nearly filled the latter that cleaning was necessary. Before beginning that work, Mr. Griggs and two other men passed through 2.26 miles of the sewer, on a tour of inspection, beginning above backwater, near the lower end. The results of the inspection and the work of cleaning the sewer are described by Mr. Griggs as follows:

The air was good at all points, and there was little or no odor; water was found from 12 to 15 ins. deep, and mud and water from 24 to 27 ins.; the deposit was mostly road detritus, mixed and stratified with layers of tar from ⅛ to ¼-in. thick, from 1 to 2 ins. apart; where the larger sewers crossed, gravel and boulders from 2 to 10 ins. in diameter were mixed with the detritus for a distance of about 200 ft.

The sides of the sewer above the water lines, in places, were slimed with sludge from ⅛ to 4 ins. thick, the thickest deposits being irregular in location and in thickness; occasionally the sludge would extend to the roof of the sewer, but usually this did not occur.

The seepage of the ground water into the sewer was not great, the roof being usually only damp and not wet; spurting streams were very infrequent except between State and Capital Sts., where perhaps 50 jets of water, none larger than about 3-16-in. in diameter, were found; the seepage, such as it was, usually came in below the spring line of the arch.

From Peters Run to Mound St. the seepage water carried iron in solution, and from Mound St. to Capital St. lime or magnesia were in the seepage water, so that a scale of the same, which glistened like marble, was deposited on the sides over the sludge in a layer about 1-64-in. in thickness.

A 6-in. pipe connection at Court St., entering the sewer above the spring line, was nearly half full of lime deposit, which projected into the intercepting sewer and formed a deposit down the sides of the sewer 9 ins. in width for 13 ins.

Toadstools, up to 3½ ins. in diameter, in all stages of growth and decay, were found on the sides and top of the sewer in abundance, and under the part having a cover of about 40 ft., in the vicinity of State and Town Sts., the mycelium of a fungus common in coal mines, which resembled the tough fibrous roots of a tree, was found 9 ins. in length, growing in patches from the top of the sewer; and in one place a thick bunch or cluster, 20 ins. in diameter and 30 ins. in length, was attached to the side of the sewer above the spring line.

As the sewer diminished in diameter and the deposits increased in depth, the labor of inspection was quite fatiguing, and required a crawling position and progress forward on hands and feet.

In the construction of the sewer provision was made for intercepting connections by inserting a stone in the side at the spring line, about 24 x 30 ins., in the shape of a cross, with a 12-in. hole in the center, and another stone on the opposite side of the sewer and in the invert to receive the force of the falling stream. None of the openings so provided have been used—the intercepting pipes which were laid enter near the top of the sewer or at some manhole.

The brick work of the sewer is generally in excellent condition; the mortar is good, the joints sound; no soft bricks were found. In three places south of Peters Run cracks in the roof ¼-in. in width for 50 ft. in length were noted. In places mortar that dropped on the invert during construction was not always cleaned off as carefully as could have been desired, thus producing an unnecessary roughness.

North of and near Moler St. there are three depressions in the invert, 1 ft. wide by 2 ft. in length, where brick for the top courses of the invert seem to be gone.

The cleaning of the sewer was begun Sept. 21 and has continued uninterruptedly to date of Jan. 1, 1900; 2.26 miles have been cleaned.

In cleaning, four men to a gang and six gangs were employed, each furnished with 20 stout, wooden buckets, a flat-bottomed boat 2 ft. wide by 10 ft. long, capable of holding ten loaded buckets, an 8-ft. tripod with a pulley at the apex over the manhole, and rope with hooks on each end over the same and into the sewer. With wages at 15 cts. per hour, the labor cost of cleaning has ranged from $1.32 to $1.87, averaging $1.65 per cu. yd. on the basis of the number of bucketfuls removed multiplied by the cubical contents of a bucket, which was 0.53 cu. ft. The cost per lineal foot of sewer cleaned has been 30 cts.

It is believed that no tar has gotten into the intercepting sewer from the Columbus Gas Co.'s works, as none has ever been observed in the Spring St. sewer into which it drains. There is, however, a large quantity of tar in the intercepting sewer above the Spring St. sewer.

A tar collecting chamber was constructed in West St. on the Penitentiary sewer, in December, 1899, toward the cost of which the State paid the city $75. By a careful watching of this chamber the sewer and drainage department can know in the future whenever tar is escaping, and take measures to prevent its entering the city sewers.

To the date of December 31, 1899, there had been spent on the cleaning of the intercepting sewer $3,608.

At our request, Mr. Griggs has very kindly supplemented the foregoing by an account of the continuation of this work in 1900, and a summary of the cost of the whole work, as follows:

The cleaning of the intercepting sewer was prosecuted continuously from the beginning of the year until June 1, 1900, covering in that time a distance of 2,922 ft.

This portion of the sewer was so nearly full of deposits that it could be attacked only from the lower end, thus limiting work to a day and night gaug, and materially increasing the distance to be traveled. The diameter was from 4½ to 4 ft., requiring the narrowing of the boats, so that their capacity was reduced from ten to six buckets.

For these reasons the labor cost per foot of sewer cleaned in 1900 was $0.987. The number of cubic yards removed was 1,596.

Cost of labor, per cu. yd.	$1.80
Cost of tools and supplies, per cu. yd.	.05
Total cost of labor, tools, and supplies, per cu. yd.	$1.85

Expenditure for cleaning intercepting sewer from Sept. 21, 1899, to June 1, 1900:

For labor	$6,306
For tools and supplies	259
Total	$6,565

Total number of cubic yards removed, 3,677.

Cost of labor, per cu. yd.	$1.715
Cost of tools and supplies, per cu. yd.	.070
Total	$1.785

The upper part of the sewer was found to be in no special need of cleaning, as the inlets are small and catch-basins on tributary sewers less frequent. A suitable flushing stream at its upper end would clean it effectively, which can be arranged by constructing 120 ft. of 24-in. sewer and a controlling head gate at the river.

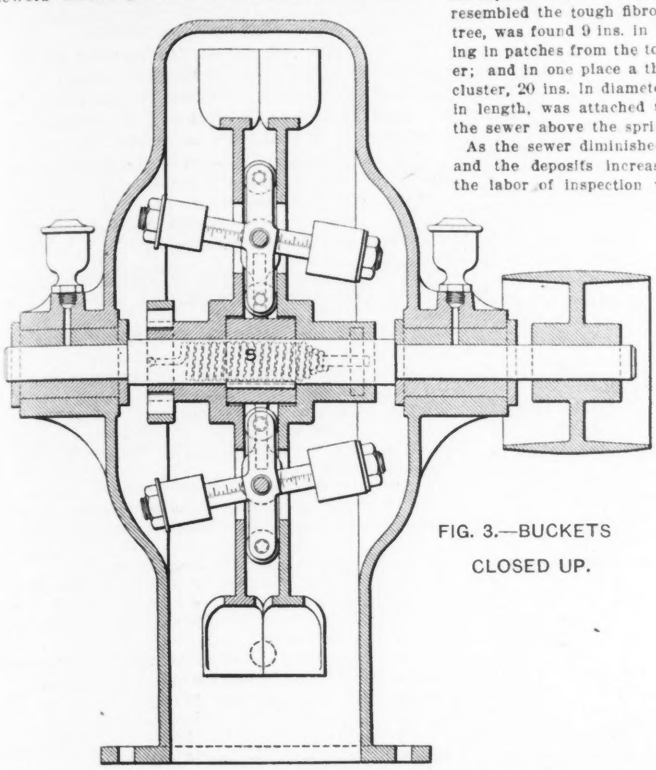

FIG. 3.—BUCKETS CLOSED UP.

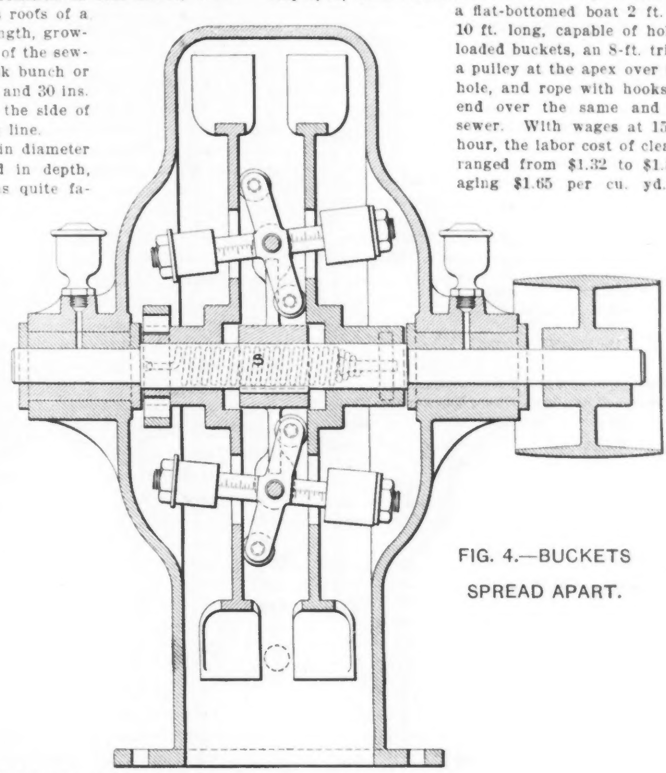

FIG. 4.—BUCKETS SPREAD APART.

FIGS. 3 AND 4.—LONGITUDINAL SECTIONS OF THE CASSEL WATER-WHEEL.

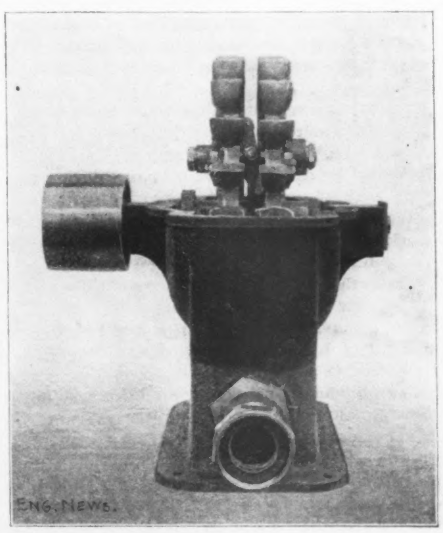

Fig. 5.—The Cassel Water-Wheel with the Lower Part of Casing, Showing Halves of Wheel Separated.

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"Where combination is possible, competition is impossible." A new illustration of the truth of this familiar saying in the field of natural monopolies is furnished by the recent purchase of the Pennsylvania Coal Co., by interests closely identified with the Erie R. R. Co. This absorption means the abandonment of the Delaware Valley & Kingston R. R., the projected independent railway line, for the carriage of anthracite coal to tidewater on the Hudson River at Kingston, N. Y. As our readers will remember, this proposed road was projected by the independent anthracite operators, who have long protested against the exorbitant rates charged by the railways for the transport of anthracite to market. The enterprise secured abundant financial support, and was formally approved by the New York Railroad Commission, notwithstanding the protests of the railways whose traffic the new road would divert. As it was evident that those back of the new road were in earnest, and were able to carry the enterprise to completion, the purchase of control in the new enterprise was determined upon by financiers identified with the principal coal carrying railways, and the price of the stock was run up on the New York exchange from 425 to 740 in a single week. The final transfer was made at a price which nets the stockholders about 752% of the par value of their holdings. As the capitalization of the Pennsylvania Coal Co. was $5,000,000, it will be seen that the transfer involves about $38,000,000, and is somewhat instructive as to what it was worth to the anthracite roads to prevent the entrance of a competitor into the field they have so long monopolized.

We have long maintained that the remedy for exorbitant railway rates must be sought in direct Government control, and that the attempt to introduce competition to protect the public against extortion was doomed to certain failure. The fate of the Delaware Valley & Kingston Ry. enterprise furnishes new proof of this. It is true that the projectors of the competing road have reaped handsome profits; but the public is worse off than before, for a new burden of interest-bearing and dividend-bearing securities has been or will be created for the anthracite traffic to bear. The public will doubtless be officially informed at a later date that the price of coal has gone up on account of higher wages to the miners!

The paper on the design of locomotives, by Mr. W. H. Marshall, published in this issue, is the best general statement of present-day practice in the motive-power department of American railways of heavy traffic that has appeared in a long time. It is worth especial notice that the present limit to the size of locomotives, the length of trains, and reductions in the cost of moving heavy freight, is fixed by the condition of the permanent way, and not by the rolling stock. In other words, Mr. Marshall indicates that the designers of locomotives are prepared to build as large engines as the track and bridges will carry, and he does not at all overstate the economies which result from recent advances in locomotive practice.

On the other hand, it should be clearly understood that Mr. Marshall's paper relates only to the class of railways which he specifies; and while it is an admirable statement of up-to-date practice on such roads as the Lake Shore and the trunk line railways generally, and also of the coal-carrying roads and some parts of the transcontinental roads; it does not apply at all to a large proportion of the mileage of American railways, such as the branches and feeders of the trunk lines, the numerous roads of only local importance and many main lines in thinly-populated districts. Railways of this latter class are under entirely different conditions from the roads whose annual traffic is counted in millions of tons, and the heavy locomotives which have so cut down expenses on the trunk line roads would be of no benefit on their local branches and feeders. Progress in this field will probably lie in the direction of making the locomotive lighter rather than heavier, and enabling the necessary train service to be maintained at a smaller cost.

SOCIAL ENGINEERING.

At this Christmas season, we know of no more appropriate subject for discussion in this column than the betterment of conditions of life among the world's workers, and the growing extent to which systematic work of this character is being carried on.

Some typical examples of this work have been presented with much interesting detail in some recent publications,* and we strongly advise their careful perusal by all who have responsibilities in connection with the conduct of manufacturing or other enterprises involving a large labor force.

The work for the benefit of employees described in these publications varies all the way from mere contributions made by employers to social clubs or similar organizations among the workmen, to the remarkable system of social improvement developed by the National Cash Register Co., of Dayton, O.

At this establishment, and at some others which are following along somewhat similar lines, the various schemes undertaken require so much thought and attention that one or more men or women are required to devote their whole time to this work. It is even said that there is growing up a demand for trained workers in this field. Mr. Tolman, in the December "Century" (see footnote), tells how he was consulted by a man who desired to do something for his employees. After some conversation between the two, during which the employer exclaimed that the plans outlined by Mr. Tolman would require more time than could be given to the work by his executive staff, Mr. Tolman said:

> . . . you need some one on your staff whose sole business will be the planning and direction of movements to improve industrial conditions. In other words, you need a social engineer.
>
> Social engineering (Mr. Tolman then adds in his article) is a new profession, and the above facts show that there is a demand for experts in this line. Will the members of the profession be recruited from our colleges?

The lines of work already undertaken for the betterment of employees' welfare, as found in successful operation in the establishments visited by Mr. Olmsted in behalf of the U. S. Department of labor, are summarized as follows:

> (1) Club organizations in which employees are handed together for social, educational, recreative and other purposes incident to such associations.
>
> (2) The encouragement of physical culture by means of gymnasiums, calisthenics, baseball, bicycle and similar clubs.
>
> (3) The improvement of intellectual conditions by means of free lectures, libraries, kindergartens, and educational classes.
>
> (4) The increasing of industrial efficiency through industrial schools and manual-training classes.
>
> (5) The advancement of spiritual life by means of Sunday-schools and general religious work.
>
> (6) The cultivation of musical taste and ability by means of concerts and musical entertainments for employees, and the encouragement of musical clubs and organizations among them.
>
> (7) The promotion of improved social conditions by means of social gatherings, summer outings, meeting places, and game rooms for employees, banquets, dances, etc.
>
> (8) The sharing of profits with employees.
>
> (9) The promotion of employees' personal interest in the successful conduct of the business by encouraging and assisting them to purchase shares in it, thus, in effect, taking them into partnership.
>
> (10) The improvement of domestic conditions by means of improved dwellings, instruction in sewing, cooking, and housekeeping, and in landscape and kitchen gardening, and the exterior and interior decoration of homes.
>
> (11) The care for employees' health and comfort by means of bathing facilities, dining and lunch rooms, the furnishing of hot lunches to female employees, and by improving sanitary construction and appliances.
>
> (12) The care of sick and disabled employees and their families by means of free insurance, free medical attendance, or hospital facilities, and by the encouragement of beneficial organizations.
>
> (13) The cultivation of thrift through savings bank facilities, building associations, or provident organizations, and by the giving of prizes for valuable suggestions of employees and rewards for faithful service or the manifestation of zeal and interest in their employment.
>
> (14) The rendering of financial aid to employees in cases of hardship or distress.
>
> (15) The manifestation of interest in the personal affairs of individual employees, the cultivation of cordial and even confidential relations with them, and the promotion of their welfare in all possible ways.
>
> All the plans and ideas outlined above have been tested and are now in successful operation. The experience of the employers who have adopted such of them as the exigencies or the character of their business would permit proves that they are worthy of more general adoption, not only because of their beneficial effect upon the employed, but also for the reason that they result in decided business improvement from a purely financial standpoint.

We desire to call particular attention to the last clause of the closing sentence of this quotation, for it is emphatically the economic aspect of this subject which argues most eloquently for the extension and permanency of the movement. This is particularly true of those lines of industry in which intense competition and low margins of profit are the rule.

We do not mean by this that the employers who are engaged in putting these schemes for industrial and social betterment into effect are actuated by sordid motives. On the contrary, we fully believe in the philanthropy of these men. What we do maintain is that better care for the world's workers is not only good morals, but good business policy. As a cold-blooded business proposition, there is quite as much reason for increasing the efficiency of a man as of a machine; of seeing that one is kept well-housed, well cared for and in as good working condition as the other. There are, it is true, old-timers who go on in the old way, believing that anything is good enough for the workingman. When he fails to show up

*"The Betterment of Industrial Conditions," by Victor H. Olmsted, Bulletin, U. S. Dept. of Labor, November, 1900. "What More Than Wages?" by Wm. Howe Tolman, "Century Magazine," December, 1900. "The Betterment of Social Life," by R. E. Phillips, "The World's Work," December, 1900. The two magazine articles are profusely illustrated with excellent reproductions from photographic views. The Labor Department bulletin is a much longer and more detailed work, being the result of a careful scientific investigation. It can be obtained free by addressing a request to the Department of Labor, Washington, D. C.

or leaves the shop, are not there plenty more to be had to take his place? Doubtless there are, but of what class are they? Are they the best men or the poorest? Does not such reasoning fail to take account of the importance to any business enterprise of a well-organized, faithful and efficient set of employees? Plenty of concerns have gone to shipwreck through failure to secure this. Plenty of others have made the port of success because a working force has been built up and retained which gave the output a name and reputation for good workmanship.

And there is a great deal in that phrase. Is there ever anywhere any "good workmanship" except it comes from the hands of a good workman? We doubt if there is any question more important to the industrial world to-day than the question how to obtain good workmen. The old-time policy of picking up a working force from the chance "journeyman"—a word that in itself expresses much regarding past conditions—is being discarded. "We train up our own men to our work" is more and more commonly heard. "You can't do good work with poor tools," was the old adage; but we add to it nowadays, "neither can you do good work with poor men."

Another old-time theory—and still too commonly held—is that the employer of labor discharges his full duty toward his men when he pays them good wages for their work. It is unfortunately the case that high wages have too often conferred as much injury as benefit upon the men who receive them. In many a mining camp, for example, a large proportion of the workers who receive high wages spend the bulk of their money in drink and debauchery. Pittsburg has long been the center of perhaps the highest wage scales paid in the world; but one can go into many small factory towns in New England and see examples of workers who have reaped more benefits from much lower scales of wages than have the average highly-paid workers in Pittsburg's mills.

For the real benefit of the workers increased incomes must go hand in hand with increased desires for better living. Five dollars a month raise to a man who blows it in on a spree is a curse. The same amount to a man who uses it for the betterment of his home conditions is a blessing.

There is another aspect of this question of labor betterment which deserves notice here. That is its influence on the standing of the United States in international competition. England has long held the lead in international trade, and one great reason has been that English mechanics were better paid, better fed and more efficient than those of any other nation. The United States, however, has "seen England's hand and gone one better." It is not alone cheap iron and steel and coal that is giving us the mastery over our foreign competitors. We have and must have, to utilize our wealth of raw materials, a more efficient labor force than those in foreign shops and mills.

The century just closing has witnessed an improvement in the conditions of life among the great mass of humanity in civilized countries which transcends by far all that had been done in this direction in all the preceding centuries since the dawn of civilization. And who that looks out upon the century just dawning can doubt that this movement is only just beginning? Shall not the new years before us be marked by changes that shall make life for the millions better worth the living? Surely such work as this—the field of the social engineer—may well enlist the energies and enthusiasm of men.

Men are learning that there are nobler pleasures in life than mere money-getting and money spending. It is a worthy ambition to found or build up a great industry which shall furnish profitable employment to many. It is a higher ambition to seek to create such conditions among these workers as shall make their lives happiest. What does the term "factory town" suggest today? Does it not call to mind grimy, old buildings, crowded with tired workers, rows of slatternly tenements, interspersed with saloons—rags and offal strewn in the streets. What may it be made to mean in the light of a new century? Can we not foresee improved workshops, cleaner, better lit, better ventilated, better fit for human beings to use? Cannot the cottage take the place of the tenement, the social club that of the saloon? If the social engineer can bring about such transformations, is there not a large place awaiting him in American industry?

LETTERS TO THE EDITOR.

Rapid Earthwork Calculation.

Sir: The excellent article on this subject in your issue of Dec. 13 by Mr. H. P. Gillette furnishes a rapid and almost accurate method of calculating the volume between irregular sections. One point not brought out was, when should this method be used? Most of the sections given were five-level sections and the method of average end areas is, of course, greatly in error. In a fairly level country a good share of the sections are three-level, readings on the rod only being taken at the center and at the sides where the slope stakes are set. The most rapid way to calculate the volume between two such sections, and the usual method taught is to get the approximate volume by average end areas and apply the correction to it as given by the formula on page 144 of Godwin's "Railroad Engineer's Field Book," or a similar one on page 234 of Searles' "Field Engineering," which is

$$C = (H - H')(W - W')\frac{L}{12 \times 27}; \text{ where}$$

C = the correction in cubic yards.
H = the center height at first station.
H' = the center height at second station.
W = sum of distances out of slope stakes at the first station.
W' = sum of the same at the second station.
L = distance between the stations or sections.

This correction should always be subtracted from the approximate volume except when the smaller center height is at the same end of the solid as the greater distance between slope stakes, when it is added. This necessitates but one set of multiplications for each volume after the approximate volume has been obtained. As the quantities in this formula and also those in Mr. Gillette's are small, the use of the slide-rule will help materially and will give no appreciable error. The end areas being found by substituting in the formula for the area of a section in terms of the center height, the width of roadbed, the side heights and distances out to slope stakes, no plotting will be necessary.

With five-level or irregular sections this correction cannot be applied, and the true middle area has to be found and used in the prismoidal formula. This means a considerable amount of work, a large part of which is avoided by the use of Mr. Gillette's correction formula. As he states, no correction is necessary where the ground is approximately level.

Then, with these two simple correction formulas, the one given by most of the field books for three-level sections and his for irregular sections, there ought to be no hesitation in applying them to the average end area volumes, although the law in some of the states sanctions the use of the average end area formula on public works.

Yours truly, H. C. Ives.

Worcester Polytechnic Institute, Worcester, Mass., Dec. 15, 1900.

Modern Railway Locations Are Well Made.

Sir: Referring to Mr. Barr's criticism of railway locations in your issue of Nov. 29, and admitting justification for much that he says, his arraignment is nevertheless too severe and is applicable in a limited extent only to our day.

Whatever the character of locations 30 or even 15 years ago, the writer's observation and experience as a locating engineer in the present decade are that such work is now, as a rule, intelligently and well done. As intimated in your editorial comment, the railways now accept nothing less, and even promoters of new projects must satisfy their financial backers that the engineering work is up to date and reliable. This has raised the standard of railway location. There is no longer a place for the county surveyor.

Again, Mr. Barr has taken too pessimistic a view of the locations of the past. While they involve much of now unnecessary grades, curvature and other defects, they were made and the roads were built under conditions very different from the present; and what now appears inexcusable was then, doubtless, justifiable economy more often than the results of downright incompetency. The great trunk lines are now spending millions to improve their locations, it is true; but it was originally a financial impossibility to build the roads as they are being reconstructed.

If Mr. Barr means that 80% of the railway mileage was improperly located and, originally, could have been put on what would now be the best location, for the original cost or even within the limit of then justifiable expenditure, the writer believes he is mistaken, and that not even one road of any great length or importance has ever found it desirable or possible, on the score of economy, to improve that portion of its location.

If "the first-class locating engineers of the world are born and not made," there were probably about as many 40 years ago as now. Indeed, I am sure that an attempt to improve the early locations as a whole, keeping in mind the conditions under which they were made, will generally result in increased respect for the abilities of our predecessors of the generation gone. It is easy to see the defects in the physical layout of our railways, but by no means always possible to remedy them within the limit of economy.

Last year the writer was engaged on the main line of the Atchison, Topeka & Santa Fe Railway, between Kansas City, Mo., and La Junta, Colo., making surveys for grade reductions from 0.6 and 0.8 to 0.3 and 0.4. This required in nearly every case increase in curvature, distance and quantities, and while the enormous business of the Santa Fe now justifies a very large expenditure to secure lighter grades, the original location was the proper one for the new country traversed.

In a mountainous country there are opportunities to improve alinement, but invariably at a heavy increase in cost, while the shortening of the line generally prohibits grade reduction. This is the case with the Arizona & New Mexico Ry., on which the writer is now engaged. Here, in 12 miles, the line has been shortened, taking out about 1,200° of curvature and reducing it from a maximum of 29° to 15°; but the maximum grade could not be reduced and this improvement involves heavy tunnel and bridge work. For 20 years this road has served its purpose admirably and while the old line looks like a winding serpent as compared to the new, I have only respect for my predecessor who made the original lay out, thereby revealing and suggesting possibilities for the improvement the company now finds desirable and economical to make.

Over against "the hundreds of millions of dollars that have been worse than thrown away because of bad locations," let us set the thousands of miles of road that would not have been built on an ideal location and the case against the locating engineer will not be nearly so bad.

In revising old lines, places will occasionally be found where the new and proper location will be better and more economical than the old, viewed even from the original standpoint, but this is not the rule.

J. L. Campbell.

Clifton, Arizona, Dec. 5, 1900.

(It may be of interest to recall in this connection a remark of the late A. M. Wellington, to the effect that some of the best locations had been made in the early days of railway construction upon lines in the Eastern United States. Here the very rugged country necessitated a study of the topography and a search for the best line. Some of the poorest locations, on the other hand, were made on the level prairies of the West, in the days of boom railway construction during the '70's and early '80's. Here it was so easy, apparently, to run a railway anywhere, that the importance of good location and of keeping down the grades, was lost sight of by the early railway promoters. —Ed.)

Empirical Formulas for Steel Beams.

Sir: In the current issue of Engineering News I notice an empirical formula for the strength of steel beams. Permit me to submit some formulæ upon the same subject, which are much simpler than the one noted, and which are sufficiently accurate for practical use.

Let d = the depth of the beam in inches;
w = the weight per foot of the beam in pounds;
l = the span of the beam in feet;
S = the section modulus of the beam;
L = the safe load, uniformly distributed, in pounds;
L' = the safe load, uniformly distributed, in tons.

Then

$$S = \frac{d\ w}{10}; \quad (1)$$

$$L = \frac{1{,}000\ d\ w}{l}; \quad (2)$$

$$L' = \frac{d\ w}{2\ l}. \quad (3)$$

Formula (1) gives results substantially correct for the smaller beams, about 5% too large for 12-in. beams, and about 10% too large for beams over 12 ins. deep.

Formulas (2) and (3) are derived from (1), by using an extreme fiber stress of 15,000 lbs. per sq. in. The results, however, agree very closely with the safe loads as given in Carnegie's "Pocket-Book," which are figured with an extreme fiber stress of 16,000 lbs. per sq. in.

For Example: From (3) the safe load on a 6-in. 12¼-lb. I-beam having a span of 9 ft. is 4.08 tons. As given by Carnegie it is 4.31 tons. From (3) the safe load on a 12-in. 40-lb. beam having a span of 15 ft. is 16 tons. As given by Carnegie it is 15.94 tons. From (3) the safe load on a 24-in. 80-lb. beam having a span of 20 ft. is 48 tons. As given in Carnegie it is 46.40 tons.

The above formulæ hold good only for what are termed in the 1900 Carnegie, "Standard Weights," i. e., the lightest section rolled from each set of rolls. But the formulæ can easily be applied to rolled-up sections by remembering that the metal added to make a "rolled-up" section is practically one-half as efficient, pound for pound, as the metal in the original "standard" section.

For Example: A 12-in. 55-lb. beam is a 12-in. 40-lb. beam "rolled-up." The added 15 lbs. is equivalent to 7½ lbs. of the original beam; or, the whole beam would be equivalent to a 47½-lb. beam of the same efficiency, pound for pound, as the original 40-lb. beam. Substituting 47½ lbs. in formula (3), and using a span of 15 ft., we get 19 tons as the safe load for a 12-in. 55-lb. beam, with the given span. Figured from Carnegie's "Pocket-Book," the safe load is 19.02 tons. Respectfully,

R. W. Carter.

3953 Michigan Ave., Chicago, Dec. 8, 1900.

Sir: Having noticed a letter published in your issue of Dec. 6, entitled "An Empirical Rule for the Strength of I-Beams," I send you a much simpler rule, which I discovered several years ago, and which I have never seen published. This rule is simply the fact that the coefficient of strength of an I-beam for a fiber strain of 16,000 lbs. is approximately 1,000 times the product of the depth of the beam in inches and the weight of the beam per foot.

Taking a 10-in. × 25-lb. beam, for example: 10 × 25 × 1,000 = 250,000. From the Table of Properties of I-Beams, as given in the Carnegie Hand Book, the coefficient of a 10-in. × 25 lb. beam for a fibre strain of 16,000 lbs. is 260,000, a variation of 4%. Having the coefficient, which is the safe uniformly distributed load on a span of one foot, the safe load for any span is easily found by dividing the coefficient by the span in feet.

The accuracy of this rule can readily be verified by inspection of the Table of Properties of I-Beams in the Carnegie Hand Book. It will be seen from such inspection that this rule is more accurate for the minimum sections than for the heavier sections. In beams 12 ins. and under, of minimum section, the above product is, in all cases, slightly less than the actual coefficient, the greatest variation being 6.25% in the case of 3-in. beams. In beams over 12 ins., of minimum section, the above product is, in all cases, slightly greater than the actual coefficient, the greatest variation being 6% in the case of 15-in. × 80-lb. beams. For 12-in. × 31½-lb. beams the variation is 1.5%, and for 15-in. × 42-lb. beams the variation is but 0.25%.

This rule also applies to channels, the product being in all cases slightly in excess of the actual coefficient, the variation being less than 6% for any channel of minimum section except 15-in. × 33-lb. channel, in which it is 11%. A formula expressing the above relations may be put into several forms, but I think the fundamental fact given above is the easiest to remember. On account of its simplicity, I have found the above rule very useful, and trust it may be so to others.

Yours truly, Luther Twichell,
Sales Agent, American Bridge Co.

Minneapolis, Minn., Dec. 14, 1900.

(Two other correspondents send us letters giving Mr. Twichell's formula, which they highly commend for its practical convenience.—Ed.)

Failure of an Elevated Wooden Water Tank By Rusting of Hoops From the Inside.

Sir: I have noted with interest in your columns descriptions of several cases where water tanks have burst by reason of the rusting and breaking of the hoops, and I enclose a description of another case, which is particularly noteworthy from the fact that the tank and its hoops had been frequently painted and that the rusting of the hoops proceeded mainly from the inside surface next to the wood, which was, of course, not reached in the process of repainting and which was furthermore hidden from observation. On receiving notice of the failure, I had one of our inspectors immediately visit the mill, and I enclose a copy of his report.

Wooden tanks have a wide field of usefulness, because of their remarkable cheapness and ease of erection, but this failure, together with several others that have recently occurred, gives strong emphasis to the belief that for tanks on top of high buildings with valuable contents susceptible to water damage, true economy will be found in tanks of riveted steel plates, which can be both inspected and thoroughly repainted inside and outside, and which, if penetrated by rust, will fail slowly, instead of by an instantaneous collapse.

These failures of tanks with flat hoops from rusting of the hidden inside unpainted surface indicates the superior durability of hoops made of round rods with upset ends and united by screw-nuts held off from the wood by well-designed iron shoes; since these round rods expose comparatively less surface to corrosion in proportion to net area and can be inspected and painted over a larger proportion of their entire circumference.

Very truly yours, John R. Freeman, C. E.
Room 812, Banigan Building, Providence, R. I.,
Dec. 10, 1900.

(That portion of the report referred to above by Mr. Freeman, which relates particularly to the failure of the tank, is given below. The tank belonged to the mills of the Bamford Bros. Silk Mfg. Co., of Paterson, N. J.—Ed.)

Gentlemen: This tank was the primary source of supply to the automatic sprinklers, and held with the ordinary depth of water 8,600 gallons. It was 11½ ft. in diameter by 11 ft. 2 ins. deep, and was supported by a 12-ft. wooden trestle. Inside of the trestle and about level with the

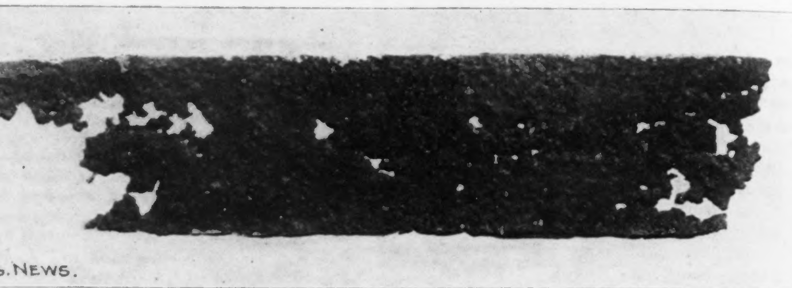


FIG. 2.—VIEW OF SECTION OF RUSTED IRON HOOP FROM COLLAPSED WATER TANK, BAMFORD BROS. SILK MILLS, PATERSON, N. J.

ridge of roof is a 7,000-gallon tank which supplies water for sinks, closets, etc. The tank which burst by failure of hoops on Nov. 27, 1900, was erected in 1892, and had been painted four times, the last being in May or June of this year. The next previous painting was in 1898.

The staves and bottom were 2⅜ ins. in thickness and held together by nine bands or hoops 3-16 × 3⅓ ins. in section, aranged as shown in the sketch, Fig. 1.

The falling hoops broke two skylights and allowed water to enter and wet down about one-fourth of three upper floors of the mills. The main body of water descended directly to the yard. No damage was done to trestle, mill-supply tank or sprinkler pipes, and apparently little to the roof except the breaking of two skylights referred to above. Seven hoops, all except the extreme top and bottom ones, parted, and eight or ten staves, distributed at four different points in the circumference, were broken 7 to 8 ft. from the top. The tank did not fall, but was taken down the following day.

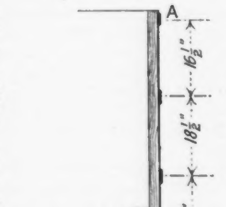


Fig. 1.—Sketch Showing Arrangement of Hoops on Collapsed Water Tank of Bamford Bros. Silk Mills, at Paterson, N. J.

An examination shows the inside of all hoops to be covered with a scale of rust of varying thickness, extending in some places entirely through the metal (Fig. 2). This undoubtedly caused them to fail, except one which sheared off the 2 rivets holding it together. The outsides of the hoops appear reasonably smooth and the scale of rust maintains the apparent thickness of the metal, so that the defect would hardly be discovered except by a careful examination. There is no paint inside of the hoops. The tank was apparently well cared for and ordinary precautions taken for its preservation. It has never given trouble by leaking. The staves are sound but, being water-soaked, kept the inside surface of the hoops continually moist, which evidently accounts for the rapid corrosion. If this inside surface could be treated in such a manner as to prevent this action, the main difficulty would be overcome. The need of careful inspections of all tanks is also evident. A further defect in construction appears in the weakness of the joints of the hoops which in this instance caused one to fail by the shearing of the rivets. It will be noted from the sketch, Fig. 1, that the hoops were not properly arranged.

Respectfully submitted, William E. Stanley,
Inspector Factory Mutual Fire Insurance Companies.

Boston, Mass., Dec. 3, 1900.

State Good Roads vs. Government Roads.

Sir: In your issue of Nov. 29th, in referring editorially to the recent Good Roads convention, held at Chicago, you make statements somewhat at variance with the facts, at least as observed by one who was present at every session of the convention.

You say "The feeling was freely expressed that the government ought to make large appropriations for the construction of good roads." No member of the convention expressed such an opinion, and I question if a single delegate entertained such. Knowing well what the attitude of all good-roads advocates is on this question, and that nothing contrawise appeared in discussion at the convention, it thus seems to the writer that your little sermon beginning with "The idea that the national government should undertake the improvement of common roads is based, etc.," was quite inopportune.

In concluding your report of the work of the convention, you assert without qualification that after the reading of Mr. E. G. Harrison's paper the rest of the session of the 21st was wasted in matters having no relation to the objects of the convention. Whether the time allotted to Mr. Patullo was wasted or not was for the convention to pass judgment—rather than a paper depending upon the local press for its information, or if having a representative, he was most successfully conspicuous in the proverbial way. This judgment was passed by the convention both in granting Mr. Patullo the 30 minutes for his address and again after the address by a hearty vote of thanks for the inspiration his words had been to the convention.

It is our own conviction that the time of the convention given to Mr. Patullo was not wasted though having nothing to do with good roads—if we except the common avenues of kinship and good fellowship. If it did no good to the cause it is a reasonable guess that it did no harm, which cannot be safely said of the slurs appearing in your columns relating thereto. Vide "* * * but a majority seemed to be willing to take anything that came along."

If you are an earnest advocate of reform relating to the conduct of our public highways your methods of showing such advocacy are likely to be misunderstood, for they have the outward appearance of being unkind—to give it the most charitable interpretation. If you differ with the recognized leaders in this movement as to plans or methods, the cause will surely profit by a dignified presentation of such issues.

And now a word in answer to your argument or rather your admission of "seeing no reason why public education in methods of road improvements cannot be as well, or better, conducted by the separate states as by the general government." About 10% of our public highways are essentially state and interstate in character and might come under the supervision of the federal government as logically as our rivers are now treated for purposes of navigation. What country in the world has been able to construct and maintain an acceptable system of highways without government aid?

And, further, it does not appear that any of these countries, having once abandoned the local plan for that of national supervision of the state roads, have returned to the plan once proven inadequate and expensive.

For the best supervision of our state highways, when we are once entered upon some plan which will lead to the construction of permanently good roads, the state is generally conceded to be, in this country, the best unit. But during the period of education, upon which we are not more than well entered, the plan of directing these initial movements, of encouraging local activity, of furnishing small object lessons, in the several states where the conditions are suited to receive the greatest benefit, is meeting with marked success.

Indeed, it is recognized by all who have watched the good roads movement during the past few years that among the four great forces at work, viz.: The wheelmen, the manufacturers of road machinery, the National Office of Road Inquiry, and the maker of automobiles, the national agency has been the most economical and helpful.

W. R. Hoag.

University of Minnesota, Dec. 10, 1900.

(In reply to the third paragraph of our correspondent's letter, we may remark that the report which he criticises was not compiled from local newspaper reports, as he surmises, but was written by a member of the editorial staff of this journal who was in personal attendance upon the sessions of the convention.

As for the editorial "sermon," the comparison made in the opening speech of the President between the National Government's appropriation for "good roads" and for river and harbor improvements, and the ebullition of the delegate who favored a combination of Good Roads and greenbacks as a national policy, appeared to us at least to show which way the wind was blowing.

Our correspondent asks, "what country in the world has been able to construct and maintain an acceptable system of highways without government aid?" The identical fallacy which we endeavored to expose is that the government has no money to spend in aid of road improvement or anything else, other than that drawn from the pockets of the people. No; the people must pay for good roads when they have them, in any case, whether the county, the state or the nation does the work. The real question, then, is, under what administration can the taxes paid for highways be most economically and efficiently expended, and under which will we be most certain that the burdens of taxation will be borne by those who derive the benefits? No one who knows and understands the evils attendant upon Congressional appropriations for Rivers and Harbors and for public buildings would ever wish to see huge appropriations for "good roads" added to the list of things for which it is a Congressman's duty to scramble to get his district's share.

We might make reply to our correspondent's claims for the work of "public education" carried on by the National Office of Road Inquiry; but the defects in this work have been already shown in these columns.—Ed.)

Assessing the Cost of Good Roads Upon Their Users.

Sir: I have read with more than usual interest the recent articles in Engineering News on the subject of "Good Roads," and was especially pleased with your editorial on the subject in your last issue. In this I think you hit the nail squarely on the head, only you did not hit it hard enough, and stopped too soon. Of course there is no sense or justice in asking our general government to go into the road building business and construct roads all over the country, as you say, nor can I see that there is any justice in even asking the individual states promiscuously to build roads within their bounds, as is customary now, I understand, in some of the Eastern states.

As you stated in your editorial mentioned above, road improvement conditions vary greatly, not only within the bounds of the United States, but within the bounds of each state, county and even township, so that the benefit is purely local and hence the assessment should be purely local, or as nearly so as possible. The question of who should pay for the construction of good roads is one that certainly is open to much argument. In the case of improved streets in cities or towns, there is in the majority of cases a great amount of benefit derived by the construction of the same to the abutting property along the line, much more, in fact, than to any other section or class of people. (It is a wonder that some one has not proposed to construct streets in some of our principal cities with some of Uncle Sam's surplus millions.) In the case of rural or country districts, however, the conditions are entirely different and the benefit to abutting property by the construction of a paved road along the same is nowhere near as great in proportion as in the case of city streets.

The method employed in most cities of assessing the whole or at least the greater portion of the cost of any improvement against the abutting property is certainly about as just a one as can be gotten, but to follow this out in the case of country highways would be most unjust and would work a hardship on most land owners that they would be unable to stand. The benefit to any farm may be said to be only such as is derived by all farms that are tributary to the improved highway whether they are directly on the same or are one, two, three or more miles away from it. The road will be used as much by the farmer three miles away from it as it is by the one directly on it, providing it is the shortest and easiest road to his market. On account of this fact it is often customary to assess the cost of road improvement upon certain tributary districts, or for each township or county to build the roads within their bounds. In forming these arbitrary bounds, however, and in determining which roads shall be improved in any township or county, there is always dissatisfaction and certainly much injustice done to certain owners and where the matter is sometimes brought before the people to be decided by popular vote, as the law requires in some states to determine whether a certain district shall construct a road or not, it is more often defeated than otherwise simply because certain numbers of the people protest against paying for an improvement that is at a distance from their own property and from which they receive no benefit whatever.

In the case of country highways the benefit is almost entirely to those who use the road and little or no benefit is derived by any one else, and hence the users are the ones that should pay for the cost of construction. The only possible way that the users can be assessed for the whole cost and each user assessed his just proportion, which, of course, is proportionate to the number of teams and the distance traveled by each, is by the method of toll collection, such as was in vogue many years ago all over the country and is to-day in many sections. The public toll road under private ownership was a godsend in its day and probably had as much to do with the settling up and development of our western country as any other single enterprise, but of late it has grown much in disfavor on account of the general change in conditions and public sentiment in regard to the private ownership and control of public franchises. So that all toll roads are gradually being bought up by the township or counties in which they lie and are thrown open to free public travel.

Still I think the toll-road solution is the only feasible one of this very difficult "good roads" problem. It is all well enough to talk about the construction of highways by state and national help, and to talk of fine rock or brick paved driveways across the continent from one end to the other, but when one stops to think that there is probably something over 10,000,000 miles of public roads in this great country of ours and that at the low figure of $5,000 per mile it is likely to take something over 50 billion dollars to make hard roads out of them, one can understand that it would require at least a year or two to complete this great work, and by the time the last one is finished it will be nearly time to start on the first again and build it over. It is rather more than likely, however, that before the last one is completed we will have no further use of "good roads," but will be hustling around in flying machines propelled by perpetual-motion machinery!

The great trouble is that most of our hardest workers and most earnest advocates of the cause of "good roads" are men who are enthusiasts on the subject of cycling or automobile propulsion. Their sole aim and endeavor is to get good roads particularly in the district they are most interested in, and incidentally all over the country, so that locomotion may be easily had to any point they might desire. They are very hard and earnest workers in their particular way, but everything that is attempted by them is done without any consideration of the one great economical feature of the case, that is, as to who should properly pay for this road improvement. That it will have to be paid for is self-evident. They are as a rule ready to stand their just proportion of the cost, but for them to do it all is out of the question, so they very naturally look to where the money is apparently most plentiful—to their state or national government. They lose sight of the fact that the use to which they would put the road is but a very small proportion of the use that would be made of it by the farmers and those whose business necessitates daily trips back and forth along the highway. Certainly the only way to make each one of these bear his just proportion is by the system of toll collection. The plan I would suggest is to apply the toll system without the objectionable feature of private ownership and control, or to go more in detail, my idea is as follows:

Let the state government pass a law authorizing townships to construct hard roads within their bounds to be paid for by toll collection. At the same time the governor should appoint a State Highway Commissioner, who should be a competent civil engineer, experienced in general road construction, paving and such matters. In any township where it is desired to construct a hard road, a petition signed by say 20 residents along the highway wanting the improvement must be presented to the town clerk, who will immediately call an election of all voters of the township to vote on the question of whether the road shall be constructed or not. If it carries, then the State Highway Commissioner shall be notified and he will visit the locality and thoroughly acquaint himself with the amount of travel and all the conditions of the surrounding country and everything that may have any bearing on the matter. From these facts then he will decide what shall be the character of the improvement. To this end to insure a certain amount of uniformity throughout the state, he shall have certain prescribed rules to follow in deciding as to the character of the improvement, the idea being always to put down the very best pavement that the prospects of the tolls paying for the same in a period of 10 years will warrant. He will then issue a permit for the construction of the road and authorize the township to issue bonds to pay for same, the road to be constructed under plans and specifications furnished by the State Highway Commissioner, who shall have supervision of the work till it is finished. The road is then to be operated for a period of 10 years as a toll road. At the expiration of that time the township may elect to pay the residuary debt, if any, by raising money by general taxation, or may extend the toll system for a period of five years more, at which time it must all be paid or the township will have to pay the balance. The road will then be a free road, to be maintained by the township. To provide against overburdening the township, it should not be permitted to have road bonds outstanding at any one time in excess of 10% of the total value of taxable property in the township. With such a law as this in operation it would be an easy matter to induce property owners or voters to vote for road improvement; and this under existing laws is the most difficult matter of all in starting work of this kind. It would insure the best possible improvement that was admissible under the existing conditions and would give the best guarantee possible of the work being done properly and in a thorough manner, which is one great drawback in present methods. Of course there are many details not mentioned that would be necessary in order to make the law operate satisfactorily and to the best advantage. The above, however, are the main features of a bill that will probably be submitted to the general Assembly of this state this coming spring.

It is not the intention that this law should repeal previous laws, or prevent road construction by special assessment, or general taxation, or any other method now in vogue, but it is intended only as another help to secure this much-needed improvement. Perhaps there are some roads that it would be impossible to construct by this method, but by making it a practice to construct highways in certain groups so as to have each group include one or more main highways, and all or as many tributary roads as could be consistently brought in, this factor of impossibilities would be reduced to a minimum.

The value of well-paved roads all over the country is certainly beyond estimate, and when we once get them we will wonder how we got along without them before.

Yours truly,

E. G. Helm, Assoc. M. Am. Soc. C. E.

134 Collinsville Ave., East St. Louis, Ill., Dec. 3, 1900.

(It seems to us that one serious objection to the toll-road plan is the cost of collecting tolls. The annual cost of maintaining a single toll-gate and toll-house and providing for its attendance would pay the interest on the cost of a mile or two of good roads.—Ed.)

Notes and Queries.

Our attention has been called to a misstatement in the article on the failure of the water tank at Cedar Falls, Ia., in our issue of Dec. 6, 1900. Mr. H. C. Hemenway is not now the city attorney of Cedar Falls and did not so sign himself in the letter which we printed. The words were added by the editor, in the belief that Mr. Hemenway still held the office named.

Through an unfortunate slip of the pen, the title of the paper describing the septic tank experiments at Pawtucket, R. I., on p. 435 of our last issue, located the work at Woonsocket, instead of Pawtucket. Woonsocket has sewage receiving tanks and filter beds, but has not, so far as we know, made any experiments with the septic tank.

BOOK REVIEWS.

THE LAW OF OPERATIONS PRELIMINARY TO CONSTRUCTION IN ENGINEERING AND ARCHITECTURE.—By John Cassan Wait, M. Am. Soc. C. E., Assistant Corporation Counsel, New York city. New York: John Wiley & Sons. Cloth; 6 × 9 ins.; pp. 638; illustrated. Cloth, $5; sheep, $5.50.

As the author well says in his preface, this book might consistently have been made a second volume of his excellent treatise on "Engineering and Architectural Jurisprudence" (Eng. News, Feb. 10, 1898). Briefly defined, the present book treats of the law attending those operations which precede construction, while the earlier book was a presentation of the law of construction. Its character and scope is indicated by the chapter headings, which are as follows: Introduction—Property Defined; Ownership of Lands—Estates; Title to Property—How Acquired; Conveyances of Lands—Essential Elements of Deeds; Water—Riparian Owners—Appropriation of Water; Waters for Irrigation in Arid Countries; Detention of Waters of Streams—Mills and Mill Rights; Diversion and Obstruction of Waters—Streams; Protection of Banks and Structures from Water; Supply of Water and Ice—Water Companies and Water-Works; Water-Rights in Regard to Surface Water; Fouling and Pollution of Surface Waters and Streams; Navigable Waters—Public and Private Rights in Navigable Water; Subterranean or Underground Waters; Oil and Gas—Ownership and Appropriation of Oil and Gas; Electricity—Property Rights Affected by the Use and Discharge of Electricity; Light and Air Incident to Land; Property Rights Defined by Boundary Lines—Lateral Support; Interference or Invasion of Property Rights by Surveyors; Boundaries in General—How Described, Established and Maintained; Boundaries on Waters—Shifting Character—Accretion, Erosion, Reliction and Reclamation; Boundaries on Waters—Land Bounded by, Along, Upon or On a Stream or the Bed, Bank, Beach or Shore; Boundaries On Lakes and Ponds; Boundaries On Islands; Boundaries on Streets and Roads; Boundaries Determined by Arbitration; Boundaries Established by Agreement or Acquiescence; Adverse Possession—Title and Boundaries to Land Affected by It; Construction, Interpretation and Application of Descriptions; Description—Conflict of Calls; Determination and Proof of Boundaries; Easements in General; License—Revocable and Irrevocable; Prescription and Prescriptive Rights; Dedication of Rights in Land to Public; Easements—Rights of Way in General; Right of Way of Railroad; Rights of Way of Street Railways; Right of Way for Telegraph and Telephone Lines; Rights of Way in Conduits, Pipe Lines, etc., for Water, Oil, Air, Gas and Electricity; Character and Kinds of Franchises.

In its treatment of these numerous subjects the present book, like its predecessor, is clear and concise, and, as we recommended that the former book should be owned and used by every engineer in independent practice and every contractor, so we recommend the present volume.

THE CONQUEST OF ARID AMERICA.—By Wm. E. Smythe. New York: Harper & Bros. Cloth; 5 x 7 ins.; pp. 326; 9 illustrations. $1.50.

This volume deals with the economic and sociological phases of its subject rather than those pertaining to agriculture or engineering. Such a plan is well advised, since the engineering side of irrigation is far in advance of its economic, sociological and legal aspects. A large part of the arid west is suffering from arrested development, due to the legal complications over water rights and the failure of those concerned to appreciate the proper relations between land and water and also between capital and labor. On the other hand, the most notable achievements thus far wrought have rested on a proper appreciation of these factors and also of the advantages of recognizing and supplying the social and intellectual wants of mankind.

If there is any one thing that Mr. Smythe brings out with more clearness and emphasis than others it is the large part which the small farm, of 5 to 20 acres, plays in the successful development of the arid region. Next to this it is hard to say whether he puts more emphasis on the advantages of diversified crops or the necessity of associative effort, including in the latter the bringing together of unemployed, or partially employed, capital and labor. While diversified farming does not yield such brilliant results as sometimes are shown where all is staked on one crop, yet for certainty of upward progress on the part of the individual and the community, the small, diversified plot of land is far ahead of the huge wheat ranch or orange grove. In addition, diversified crops ensure most of the chief food necessities of life without cash expenditures. All these points and many more of great importance are brought out by the author.

The scope of the book may be conveyed in more detail by a glance at its contents, which are in four main divisions: Part I., "Colonial Expansion at Home," outlines some of the marked features in the past and possible future development of what the author calls "the best half of the United States." Part II. describes such "Real Utopias of the Arid West," as the Mormon settlements in Utah, the Greeley Colony in Colorado, and some of the famous irrigated sections of Southern California. "Undeveloped America" is the subject of Part III., and includes brief but pretty comprehensive reviews of the natural resources of the various Western states and what each has done or may do towards the increasing greatness of the nation. In Part IV., "The Army of the Half-Employed," the author sets forth his ideas regarding associative or co-operative effort. He would utilize idle or poorly remunerative capital in the development of homes and industries in the arid West on somewhat the same plan as has been so successfully practiced by the building and loan associations of the east, only the bulk of the capital, in this case, might be furnished, if necessary, by other than home-seekers.

The volume closes with a brief appendix on the best means of applying water to land, or irrigation proper, as distinguished from the development of water.

The book deserves, as we presume it will have, a wide reading. It is particularly desirable that it be read extensively in the East; not because the West has nothing to learn from it, for it has great need of taking its teachings to heart, but because it would do much to help the East to a better understanding of the West; not alone the material or the social possibilities of the West as a place for Easterners to go to improve their conditions, but also its aims and ideals as a portion of the American republic.

NOTES FROM CITY ENGINEERS' AND OTHER MUNICIPAL REPORTS.

BOSTON, MASS.—The first annual report of the Boston Department of Baths contains a historical review of the development of municipal bath houses in Boston, written by Mr. W. I. Cole. In 1866, the city established what Mr. Cole believes was the first municipal baths in this country, comprising five floating baths and one beach bath. These were for summer use only. The first all-the-year bath house, erected with city funds, was opened in October, 1898, on Dover St., in a crowded residence section of the city; but in 1897 a combined bath house and gymnasium, formerly presented to an athletic association, was turned over to the city. Since 1898 the development of bathing facilities by the city, under the direction of the bath department, has proceeded rapidly along many lines. The second annual report of the bath department (covering the year 1899-1900) shows that the department had in its charge 13 floating baths, 6 salt and 2 fresh water beach baths, 2 swimming pools, 2 combined baths and gymnasiums, and 1 all-the-year bath house, making a total of 26 bathing establishments, at which 2,003,718 baths were taken during the year. In addition, "the department has charge of twelve convenience stations in various parts of the city, in addition to those on the Common and Public Garden." Mr. Chas. F. Morse is secretary of the department of baths.

A general review of the main sewerage works carried out by the Metropolitan Sewerage Commission, including the investigations prior to the creation of the commission, was published last summer. It includes maps, typical sewer cross-sections and a number of half-tone reproductions of interesting photographic views. Mr. Wm. M. Brown, Jr., M. Am. Soc. C. E., is chief engineer of the commission, the offices of which are at No. 1 Mt. Vernon St., Boston, Mass.

The last report of the Boston Street Department is a notable example of the effective use of half-tones to illustrate the points which need to be brought home to the attention of the city authorities and the taxpayers. Some of the views show the beneficial character of improvements already carried out, and others show the necessity or advisability of continuing the good work. Mr. Benj. Wells was superintendent of streets during the year covered by the report, but he has been succeeded by Mr. Bertrand T. Wheeler.

The last published report of the Boston Transit Commission includes some tests of air from the Boston subway, made by Prof. Henry Carmichael. Samples collected on week days in January and February, 1899, contained from 6.62 to 9.45 parts per 10,000 of carbon dioxide (carbonic acid gas). Samples taken above the street in the central part of the city, about the same time, contained 4.5 to 5.9 parts, and air from the center of a car having 65 passengers, about to enter the subway, contained 24.97 parts per 10,000. Similar tests of air from various public buildings in Boston, made by Prof. Homer S. Woodbridge, showed

> that the air taken at the busiest hour in the most crowded station in the subway is superior to that usually provided in halls, theatres, churches, schools, etc. In this connection it may be remarked that people remain several hours in the rooms referred to, while a passenger remains in the subway but a few minutes.

Mr. Howard A. Carson, M. Am. Soc. C. E., is chief engineer of the Boston Transit Commission.

NEWTON, MASS.—A statistical summary for Newton, Mass., giving a great variety of useful information relating to municipal improvements and expenditures, is included in the last annual report of the city engineer. It occupies only two pages, but presents, in handy form, figures which it would take several hours to secure from most reports, supposing they could be found after laborious search. It is a pity that more work of this sort is not done by city officials, for the good of their own colleagues and public, primarily, and for fellow officers in other cities, as well. Mr. Henry D. Woods, M. Am. Soc. C. E., was city engineer of Newton until recently, when he was succeeded by Mr. Irving T. Farnham.

SPRINGFIELD, MASS.—A 24-in. cypress wood submerged sewer outlet was laid in the Connecticut River, at Springfield, Mass., in 1898-9. The work was done by contract, but the first contractor gave up the attempt after finding that the cofferdam method did not work well. The cofferdam had double walls of 3-in. matched spruce sheeting, the rows being about 3 ft. apart and the walls about 7 ft. apart, inside. The pressure of water on the fine sand of the river bottom forced the sand in about as fast as a steam pump could remove the sand and water. The first 80 ft. of the pipe was placed inside the cofferdam after the excavation was partly made, and was left for the winter with the shore end at grade and the river end about 1½ ft. above grade. A spring freshet carried away a part of the cofferdam, and the new contractor concluded to complete the work by lowering the pipe into a submerged trench. Two scows were fastened together and on them a boiler, hoisting engine and derrick were placed. The remainder of the cofferdam having been removed, the trench was excavated by an orange peel bucket dredge, the depth averaging about 4 ft. The section of pipe partially in place was then lowered to its bed and a 96-ft. length, on shore, was launched, taken out to position by means of a scow, and sunk with the aid of railway iron, the connections being made by a diver. At the outlet end of the pipe a special ⅛-bend casting was so placed as to discharge the sewage down-stream, but in a slightly vertical direction. A basin about 20 ft. in diameter was dredged around this outlet. This method of discharge was recommended by the State Board of Health, in preference to the earlier practice at Springfield of using a ¼-bend placed vertically, and surmounted by a short length of pipe, so as to discharge 3 to 5 ft. above the river bed. Mr. Simon C. Fraser, of New London, was the contractor for completing the work.

Another interesting piece of work at Springfield was the conversion of a section of street railway track, with an ordinary girder rail, into track with a grooved head, at the same time raising the pavement between the rails to the same level as that outside. This was accomplished by taking up the brick between the rails, laying iron castings 1 ft. in length on the inner flange of the rail, in Portland cement mortar. Before the brick were relaid they were cleaned and turned and the sand cushion was made deeper, so as to bring the new surface to the desired level. About 2,000 ft. of double track was treated in this way in some ten days Mr. Geo. N. Vaughan being the contractor. The plan followed was devised by Mr. Seth Buckland a member of the Springfield city council. An experimental section was relaid in 1898 and the work described was done in 1899. The specifications for the work were drawn by Mr. Chas. M. Slocum, M. Am. Soc. C. E., City Engineer of Springfield. The plan is virtually the laying of cast-iron paving blocks, with beveled inside joints, next to the inner side of the old rails.

WORCESTER, MASS.—A Ferguson automatic recording rain gage has been in use at the sewage purification works at Worcester, Mass., since July, 1895. The daily totals for 1898-9 are given in the last report of Mr. Harrison P. Eddy, Superintendent of Sewers, and in addition details of all falls of rain and snow from July 15, 1895, to Nov. 15, 1899, are presented, including dates of precipitation, duration in hours, total precipitation and hourly rate of same, rate per hour for 20 minutes of maximum precipitation, and period and rate of greatest precipitation. Mr. Eddy says:

> It is interesting to note that usually there are several storms annually in which there is a maximum intensity of from 1 to 1½ ins. per hour for at least one 20-minute period; that there are a few periods in which the intensity runs between 1½ and 2 ins., and that there were two periods in the 4½ years when an intensity of 2.25 ins. was reached.
>
> In addition to the periods of maximum precipitation a further selection has been made of the duration of periods of greatest precipitation and the intensity of rainfall during these periods. It will be noticed that, except in cases of very short showers, the intensity throughout these periods is very much reduced, and that it rarely exceeds 1 in., and that when ½-in. is exceded it is during a shower of less than one hour total duration, with three exceptions, namely, Aug. 31, 1895, Nov. 14-15, 1895, and June 15, 1899.

Mr. Eddy's report contains an interesting description of the work thus far done towards separating the sanitary sewage and storm water, including the building of a separate conduit in the trunk sewer leading to the purification works, and storm and sanitary sewers throughout the city. The report also contains descriptions of the new sludge treatment plant and filter beds, the former comprising sludge storage basins, stone ejectors, presses and a small electric railway for hauling sludge a mile away, to the dump. Finally, there is a "Resume of the Studies and Progress Made Toward the Solution of the Sewerage Problem," covering the period from 1865 to 1899, inclusive.

PHILADELPHIA, PA.—Protective sheathing for bridges, crossing over steam railways in Philadelphia, has given good results. Two bridges were treated in this manner in 1894, one being the Girard Ave. bridge, over the Philadelphia & Reading Ry., and the other at 49th St., over the West Chester & Philadelphia Ry. The method employed and satisfaction given are set forth in the last annual report of Mr. Geo. S. Webster, M. Am. Soc. C. E., Chief Engineer of the Bureau of Surveys, as follows:

> The sheathing applied has been of 1-in. pine dressed boards, painted on the under side where tightly covering the entire structure, and painted both sides where placed only over the several tracks.
>
> The sheathing of Girard Ave. was opened for examination in the summer of 1899, after five years of service, and

both the steel work and the sheathing were found in excellent condition. The latter received four coats of asbestos paint, the last two coats having been applied three months after the first two. The experience with wooden sheathing thur far promises reasonable durability to resist locomotive exhausts with the fuel used in this locality, and justifies its application in contemplated bridges.

The Public Baths Association of Philadelphia, although a voluntary organization, has maintained a combined public bath and wash house since early in 1898. Mr. W. L. Ross, Gaskill and Leithgow Sts., is superintendent. The city of Philadelphia, it appears from the city reports for 1899, maintained nine public baths during the summer months of that year.

PROVIDENCE, R. I.—The cost of 6-in. house connections and of 6 to 32-in. sewers at Providence, R. I., in 1899, is given in the last report of Mr. Otis F. Clapp, M. Am. Soc. C. E., City Engineer, as shown in the accompanying table:

Cost of Sewer Work at Providence, R. I., in 1899.

Size.	Kind, Etc.	Average nature of excavation	Average Depth of cut, ft.	Average Cost, lin. ft.
6-in.	Drains to curb line	Fine sand; dry...	8.90	$0.50
6-in.	" " "	Sand, gravel; dry	10.50	.48
6-in.	" " "	Sand, gravel; wet	10.50	.75
6-in.	" " "	Filling; wet......	10.50	1.00
8-in.	Basin connections..	Fine sand; dry...	8.00	.30
8-in.	" " ..	Sand, gravel; dry	8.00	.47
8-in.	" " ..	Sand, gravel; wet	8.00	.45
8-in.	Sewer.*	Fine sand; dry...	9.20	.45
8-in.	"	Sand, gravel; dry	11.67	.67
8-in.	"	Sand, gravel; wet	11.67	1.00
8-in.	"	Rock............	11.67	.50
12-in.	"	Fine sand; dry...	6.20	.40
12-in.	"	Sand, gravel; dry	12.00	.73
12-in.	"	Sand, gravel; wet	12.00	1.25
12-in.	"	Rock............	12.00	.65
12-in.	"	Filling; wet......	12.00	1.25
15-in.	"	Fine sand; dry...	6.10	.30
15-in.	"	Sand, gravel; dry	12.25	.83
15-in.	"	Sand, gravel; wet	12.25	1.50
15-in.	"	Rock............	12.25	1.00
16-in.	Brick (single c'rse)	Sand, gravel; dry	12.33	1.50
18-in.	" " "	" " "	12.50	1.65
20-in.	" " "	" " "	12.67	1.61
20-in.	" (d'ble invert)	" " wet	12.33	4.75
22-in.	" (single c'rse)	" " dry	12.83	1.68
24-in.	" " "	" " "	13.00	1.50
28-in.	" (double "	" " "	13.33	2.00
30-in.	" " "	" " "	13.50	3.00
30-in.	" with 8" rider	" " "	26.50	7.00
30-in.	Iron, with 8" rider	" " "	5.00	5.00
32-in.	Brick (d'ble c'rse)	" " "	13.67	3.00
Ave. cost building 237 manholes, each				13.05
" " 100 catchbasins, each				12.94
" " 31 extra inlets, each				7.13

*Sizes of pipe sewer.

NEW YORK, N. Y.—Two lines of sewers in streets occupied by electric and street railways in New York, borough of Manhattan, are suggested in the last report of the department of sewers, owing to the difficulty of getting at sewers in the center of the street. Mr. Jas. Kane is commissioner of sewers.

ALTOONA, PA.—A handy little manual is issued yearly by the city of Altoona, Pa., in vest pocket size. The manual for 1900-1, compiled by Mr. W. J. Hamor, City Clerk, contains a wide range of useful information about the city, its officials, public works and finances. Mr. Harvey Linton, M. Am. Soc. C. E., is city engineer.

WASHINGTON, D. C.—A brief historical sketch of the pavements used at the national capital up to about 1890, written by Mr. Geo. H. Bailey, formerly in charge of the street department, is given in the report of the engineer department of the District of Columbia for 1898-9. The report also contains tables showing, by streets, the cost per square yard of repairing asphalt pavements each year after the expiration of the guarantee, the period running as high as 21 and 22 years, in a few cases.

COLUMBUS, GA.—Shell rock macadam was put down on one street in Columbus, Ga., in 1899. The same material has been used two or three years at Macon, Ga. It is quarried at a point on the Georgia Southern & Florida R. R., about 30 miles south of Macon, crushed and shipped by rail. The stone was placed on a subgrade previously compacted by means of heavy steam rollers. A 7-in. layer of loose stone was compressed to 6 ins. by rolling, a light horse roller being followed by a 12½-ton steam roller. The cost of this macadam in place was 49.52 cts. per sq. yd., of which 41.05 cts. was for railway transportation and 8.47 cts. for unloading, spreading and rolling. The rock was unloaded from the cars "right alongside the raodway where it was laid," and "the excavation for the road bed was very light." The rock compacts readily and solidly, "presents a smooth and even surface to traffic, does not become slippery in wet weather, is not so noisy as macadam or brick, and is not easily eroded or washed on steep slopes." Mr. R. I. Johnson is superintendent of public works at Columbus, Ga.

DETROIT, MICH.—Street paving guarantees, on all classes of new work except asphalt, were abandoned in Detroit, beginning with the fiscal year 1899-1900. The board of public works states that with close inspection it looks for better results under the new plan, particularly as contractors, when urged to do better work, cannot plead that they have given a guarantee. Cedar blocks are in favor, more particularly for residence streets, both with the board and with citizens. This is partially due to their cheapness in Detroit. During the year, 34 streets were paved and 27 were repaved with cedar blocks on a concrete foundation, the cost for new work averaging $1.52, and for repaving, $1.18 per sq. yd. Not a yard of sheet asphalt was laid during the year, owing to the continued high prices bid, the board advertising seven times for the same work, in the hope of securing what it considered a fair bid.

Three quick repair wagons were used by the sidewalk department of the Detroit board of works in 1899. Whenever the police or citizens report defective wood sidewalks one of the wagons hurries to the spot and puts in a new plank or fastens down a loose one. Repairs are thus a matter of hours, instead of days, as formerly, and many damage suits for personal injury are averted. It seems a pity to have to record that 40½ miles of wood sidewalks were laid in 1899-00, against only 14 miles of stone walks. Mr. Robt. H. McCormick, M. Am. Soc. C. E., is city engineer of Detroit.

The gross cost of arc street lighting in Detroit is given in the last report of the public lighting commission as $66.45 for an average of 1,963 lamps for the year ending June 30, 1900. This includes interest at 3% and depreciation at 4% on the investment, and also an estimate of taxes lost, or the amount of taxes that would be paid under private ownership. It will be noted that there is no allowance for sinking fund charges, and that 3% depreciation is low. It also appears from the report that there is no fire insurance on the plant, provision for such being contemplated for 1900-1. On the other hand, the interest and depreciation cover the whole underground conduit system, of which only about one-fourth is used by the lighting department, provision having been made for the wires of private companies, but the city not having forced those wires underground, as yet. Allowing for these items, for certain revenues of the department and for services rendered other branches of the city government, the commission is able to deduct $4.65 from the $66.45 already given, leaving its figure for the net cost of street lamps $61.76 per year. Mr. F. F. Ingram is president of the commission and Mr. Wm. M. Daly is city electrician and general superintendent of the lighting plant.

PEORIA, ILL.—A good point relating to trenching streets prior to laying pavements is made by Mr. A. D. Thompson, City Engineer of Peoria, Ill., in his report for 1899. He suggests that all such work as laying water, gas and sewer pipes should be done a year before a pavement is put down, in order to allow time for settlement of the trenches. Where notice is served shortly before paving work begins it is often difficult to get the different private companies and city departments to do their trenching and pipe-laying until the sub-grade has been formed, the delay being due, in part, to the desire to save excavation. The back-filling has no time for settlement before the paving is done.

MILWAUKEE, WIS.—Sweeping 677,211,171 sq. ft. of paved streets in Milwaukee in 1899 cost $23,371, including $1,181 for inspection fees. This is about 3½ cts. per 1,000 sq. yds. Mr. Chas. J. Poetsch, M. Am. Soc. C. E., is city engineer of Milwaukee.

MONTREAL, P. Q.—The cost of removing snow from 36.64 miles of streets containing street railway tracks at Montreal in 1898-9, was $57,916. The total snowfall was 116.4 ins., "but it fell in small quantities, from 1 to 12 ins. at a time, with numerous slight rainfalls between, so that the amount to be removed was considerably reduced." The work was done by the city, but under a contract with the Montreal Street Ry Co., the company agreed to pay the city $1,650 per mile of street cleaned. The city therefore made $2,540 on the year's work. This contract was for the five years ending Nov. 1, 1899, and in three of the five years the work cost largely in excess of the sum paid by the company. For the whole period, snow removal cost $364,597 and the company paid $266,236, leaving the net cost to the city $98,361. The mileage cleaned ranged from 28.53 in 1894-5 to 36.64 in 1898-9, averaging 32.23 miles. The depth of snowfall (not depth removed) ranged from 84.9 ins. in 1896-7 to 169.7 ins. in 1897-8. The figures for each year are given in the accompanying table. In 1892-3 the cost of snow removed was divided equally between the city and the company. The total expense was $26,407, but the snowfall and mileage cleaned are not given.

Cost of Removing Snow from Streets Having Electric Railway Track in Montreal, P. Q., for the Five Years Ending Nov. 1, 1899.

Year.	Length, miles.	Depth in ins.	Total cost.	Paid by company.	Net cost to city.	Av'g cost per mile, Actual.	Av'g cost per mile, P'rin. depth.
1894-5..	28.53	89.2	$79,682	$47,108	$32,574	$2,793	$31.31
1895-6..	31.80	114.8	72,210	52,470	19,740	2,271	19.78
1896-7..	32.00	84.9	52,373	52,800	Gain.*	1,637	19.28
1897-8..	32.20	169.7	102,416	53,402	49,014	3,181	18.74
1898-9..	36.64	116.4	57,916	60,456	Gain.†	1,581	13.58
Total..	161.17	575.0	$364,597	$266,236	$98,361‡	.....	.....
Average	32.23	115.0	72,919	53,247	19,672	$2,262	$19.43

Profits to city: *$427, and †$2,540; total of $2,967.
‡The net profit to city ($2,967) has been deducted from this sum.

In 1893-4 a contract similar to the five-year contract was made. Under it 20.02 miles of street were cleaned of snow, at a total cost of $62,489, of which the company paid $46,237, leaving $42,658 to be borne by the city. The snowfall for that year is not given. Mr. Percival W. St. George is city engineer of Montreal.

SARAWAK, BORNEO.—Some of the difficulties encountered by engineers in distant and partially civilized countries are brought out in the last report of Mr. H. D. Ellis, Commissioner of Public Works and Surveys for the British Protectorate of Sarawak, Borneo, one of the largest of the East Indies. Mr. Ellis appears to hail from Canada, judging from the fact that he is a member of the Canadian Society of Civil Engineers and of the associations of Dominion and Ontario Land Surveyors. A year or so ago we noted the obstacles Mr. Ellis had to overcome through lack of a pile driver, he being compelled to utilize native labor as best he could in sinking piles. During 1899 he secured a steam pile driver from England, but he found it "too cumbersome to conveniently handle." His experiences are best told in his own language, as follows:

The boiler is much too high, and the hoisting apparatus, instead of being the usual double or triple hoisting drum type, is apparently a ship's winch adapted to the purpose by some person quite ignorant of pile driving. The result is that only one hoisting line can be used at a time and for handling piles or timber the hammer has to be taken off the hoisting rope each time. A carriage had to be constructed to enable the boiler and winch to be transported from place to place, these with water and coal combined weigh approximately 10½ tons. The extreme weight for boiler and hoisting drums with coal and water should not have exceeded 5 tons. In the absence of any proper appliances or draft animals it was no easy matter to deal with a weight of this kind. To enable the machine to get round corners a carriage had to be constructed in two parts, revolving on a center pin, the whole weight being jacked up and the lower part of the carriage revolved to the proper direction and then rails put in place. Sixty to 90 ft. of track are laid at a time with a cross bar at the end, the machine hauling itself along by a rope attached to the cross bar. The leads of the old driver are getting shaky and will have to be rebuilt soon; this can be done as soon as the driver has completed its present work.

In spite of the weight and difficulty of handling there is still a very great saving in the cost of driving, the price varying from 50 cts. per pile to 80 cts. (including cost of fuel), according to the depth driven, whilst previously it cost from $5 to $6 per pile, and then they were not properly driven.

At places where there are many piles to drive, now that the men are more expert in handling and moving the machinery and are daily becoming more accustomed to working it, the price per pile will be reduced.

During the year the course of a drain was changed at the request of one Seng Huck, who was afraid its location in front of his house door "would affect the luck of the building." The expense of the change was met by Mr. Huck. The construction of a telephone line between Kuching, the capital of Sarawak, and Busau was delayed by the Dyak choppers who were clearing the line "refusing to work because the omens (birds) were unfavorable." After this telephone line was in use a switch box "had to be taken out and sent to Singapore for repairs, a temporary one being made at the Government Machine Shop to do duty in its place."

GLASGOW, SCOTLAND.—Coming somewhat nearer home than the wilds of Borneo, we find by examining the report of the Tramways Committee of the Town Council of Glasgow, Scotland, that the business for the year ending May 31, 1900, was sufficiently good to enable the council to pay all expenses, including interest, sinking fund and depreciation, and to contribute some $60,000 to the "Common Good" fund, after all of which there was about $225,000 to transfer to the General Reserve Fund. The contracts for changing the street railways from horse to electric traction had all been let at the close of the year and some five miles of double track was being operated by electricity. The town owns 37 miles of double and one mile of single track and leases four miles of double track, laid in 42 miles of streets. Mr. Walter Paton is Convener of the Tramways Committee and Mr. John Young is general manager of the tramways.

THE PRELIMINARY REPORT OF THE ISTHMIAN CANAL COMMISSION.

(Concluded from p. 427.)

THE PANAMA ROUTE.

The old Panama Canal Co. projected a tide-level canal 47 miles in length; but there are two great physical difficulties in the way of such a construction: (1) The line in the valley of the Chagres River would have to be excavated below the bed of that stream, and would be overflowed at times of flood. (2) The passage of the divide at Culebra would involve an excavation of unprecedented size. Before the old company abandoned work the tide-level scheme was abandoned, and various schemes were canvassed for a canal with locks, among others, one with a summit level 160 ft. above the sea, and supplied by pumping. The New Panama Canal Co. adopted a plan with a summit level at 97½ ft., taking its water supply from the upper Chagres, which was to be dammed at Alhajuela and the water brought through an artificial conduit 10.4 miles to the canal at Obispo. This plan was adopted because it made possible the completion of the canal in 8 years, the period fixed by the company's concessions from Colombia.

The Commission, however, has adopted a simpler plan, avoiding such complicated works as the conduit for supplying the summit level, believing that if the United States were to undertake the work, no such limit of time for construction at the expense of the character of the completed work would be permissible. The plan fixed upon by the Commission for the Panama work, should it be undertaken by the United States, is described as follows:

The canal, as thus projected, may be described as follows: The excavation begins at the 6-fathom line in the harbor of Colon, with a bottom width of 500 ft., and slopes of 1 on 3 through the bay and lowland 2.62 miles, of which about 1 mile is inside the shore line, forming a narrow protected harbor. The estimated cost of this entrance and harbor is $7,334,673.

From the inner end of the harbor the bottom width of the canal is 150 ft., the side slopes of 1 on 3 being retained for 1.96 miles through the swamp, after which they are reduced to the standard used in firm earth. This level extends 12.56 miles to the Bohio locks. Its estimated cost is $10,718,288. At Bohio is located a double flight of locks, having a total lift varying from 82 ft. at the minimum level of the lake to 90 ft. at the maximum, 45 to each lock; the normal lift being 85 ft. These locks are on the location adopted by the French company. The estimated cost of this flight of double locks, four lock chambers in all, is $10,982,345.

Above the locks the canal enters the artifical lake formed by the Bohio dam and known as Lake Bohio. For the first 7 miles it is a broad, deep body of water, affording room for anchorage as well as navigation. Beyond this some light excavations are necessary. At the upper end the channel would be enlarged to provide for the flood discharge of the Chagres, being given a minimum section of 50,000 sq. ft. The length of the channel in Lake Bohio is 12.59 miles from the locks to the point where it enters the cut through the divide. The estimated cost of this section is $2,786,449.

Near to the entrance to the summit cut would be placed a pair of gates 100 ft. wide, so that if it should become necessary to draw off the water from the summit cut, the level of Lake Bohio would not be affected. These gates would be at the site of a lock proposed by the French company near Obispo with a foundation on hard rock. The estimated cost of these gates is $295,436.

The summit cut is 7.95 miles long from the Obispo gates to the Pedro Miguel locks. The highest point is about five miles from the Obispo gates where the bottom of the canal is 274 ft. below the natural surface of the ground at the sides of the cutting. This is the famous Culebra cut, though the name has often been applied only to the mile of heaviest work. There is a little very hard rock at the eastern end of this section and the western two miles are in ordinary materials. The remainder consists of a hard indurated clay, with some softer material at the top and some strata and dikes of hard rock; in fixing the price it must be rated as soft rock, but it must be given slopes equivalent to those in earth. This cut has been estimated on the basis of a bottom width of 150 ft., with side slopes of 1 on 1. While the cut may not be finished with this uniform slope, this furnishes as correct a basis of estimate as can now be arrived at. The entire cut would be lined with masonry walls finishing at elevation 92, 2 ft. above high water, these walls having nearly vertical faces and furnishing benches 38 ft. wide on either side of the canal, on one of which the Panama railroad would be laid, while it is probable that a service track would be placed on the other. Much has been said about the instability of the Culebra cut; in point of fact, there is a clay in the upper portion of the deep cut which flows readily when saturated, but which will give little trouble if thoroughly drained; probably nine-tenths of the material would naturally be classed as hard clay of stable character; it would weather somewhat, and the surface might require some repairing with concrete in bad places, a practice common in deep cuttings in Europe; this clay disintegrates rapidly in water, and for this reason the canal prism should be confined between masonry walls. With the provision made for broad benches on each side, on which any slight slides would be arrested, it is confidently believed that no trouble would be experienced. The estimated cost of the 6.02 miles of heavy work is $41,940,480, and of the entire 7.95 miles between the Obispo gates and the Pedro Miguel locks, $44,378,335. It would probably take eight years to excavate this section of the canal.

The Pedro Miguel locks will be similar to the Bohio locks, the aggregate lift varying from 54 to 62 ft. There is an excellent rock foundation here. The estimated cost of these locks, including an adjacent dam, is $8,496,326.

A level 1.33 miles long extends from the Pedro Miguel locks to the last lock, which is at Miraflores. The normal elevation of the surface of the water is 28. The estimated cost of this section is $1,169,611.

At the end of this level would be located the Miraflores lock, with a lift varying from 18 ft. at high tide to 38 ft. at mean low tide. There is a good rock foundation for this lock. A spillway will be required to regulate the height of this level. The estimated cost of this lock and spillway is $5,720,363.

For 4.12 miles beyond the Miraflores lock the canal extends through a low swamp country through which the Rio Grande runs. Occasional rock is found here, but the material is generally very soft and the canal has been estimated for a bottom width of 150 ft. with slopes of 1 on 3. This brings the canal to a point known as La Boca, where the Panama Railroad Company has constructed a large and substantial wharf. A dredged channel 200 ft. wide with slopes of 1 on 3 would extend from here 3.6 miles to the 8-fathom line in Panama Bay. The first 2 miles of this dredged channel are through flats which are bare at low water, where there is a considerable amount of submerged rock. The total cost of this section from the lock to deep water is estimated at $12,366,914.

Besides the works embraced in the excavation of the canal itself there will be five outlying works which must be considered. These are the Bohio dam, the Gigante spillway, the diversion of the lower Chagres opposite Gatun, the diversion of the Gatuncillo east of Gatun, and the diversion of the Panama railroad around Lake Bohio.

The Bohio dam is the most important structure on the line. A dam of either earth or masonry is feasible, the latter being the more expensive. The French plan contemplated a dam of earth. It has been decided, however, to use the masonry type for the purpose of these estimates. The foundation must be carried to rock, the depth to which has not yet been ascertained at all points, though the maximum is known to be not less than 128 ft. below mean tide. The estimated cost of such a dam is $8,500,000.

The Gigante spillway, which is a structure of considerable magniture, is very simple. There is a good rock foundation at or above tide level for the entire length of this spillway. It would consist of a masonry dam with a crest at elevation 85, terminating in an apron at elevation 65, with a solid foundation below this level, the apron being everywhere below the present surface of the ground. The foundation, below elevation 65, would be put in first and before the flow of water through the present river at the site of the Bohio dam is checked. The water after passing over this spillway would flow across the country about a mile to the swamp known as the Marais Peña Blanca. The elevation of the surface of this swamp is now 22.3 ft., so that the water would have a fall of 42.7 ft. in this mile, which fall would be materially reduced in extreme floods by the backing up of water in the swamp. Plans have been prepared for this spillway, and the estimated cost is $1,124,524.

A channel must be cut from the Marias de Peña Blanca to the Marais de Agua Clara, the cost of which is estimated at $1,448,076.

A channel was cut by the old Canal Company to divert the Chagres from the canal opposite Gatun. This channel, however, is of very inadequate dimensions and a new channel, part of which will be an enlargement of the present one, should be cut here. It should have a cross section of 10,000 sq. ft. Rock would be encountered in its excavation, and its cost has been estimated at $1,929,976.

A diversion channel intended to take part of the waters of the Chagres was constructed by the old company along the east side of the canal to Boca Grande back of Colon. This cut across the Gatuncillo near Gatun and the portion of it north of this point is available as a new channel for the Gatuncillo. Some work must be done on it, especially at the crossing of the Panama Railroad, where the piers for a new bridge are completed. The cost of putting this channel into service is estimated at $100,000.

From Bohio to the Obispo gates the Panama Railroad must be rebuilt for 15½ miles on an entirely new location, with a bridge across the Chagres, below Gamboa. An estimate made from approximate profiles indicates that the cost of this diversion will not exceed $75,000 a mile, or $1,162,500. From the Obispo gates the railroad would be carried for 6 miles on the bench formed by the retaining wall on the east side of the Culebra cut, these 6 miles being estimated to cost $10,000 a mile, which includes only track laying, ties, and ballasting. Beyond this will be a mile of light work estimated at $25,000, while the main track will have to be raised for 2 miles farther at a cost of $20,000. Combining these figures, the total cost of the diversion of the Panama Railroad becomes $1,267,500.

Summing up the several figures already given, the total estimated cost of completing the Panama Canal is as follows:

Colon entrance and harbor	$7,334,673
Harbor to Bohio locks, including levee	10,718,288
Bohio locks, including excavation	10,982,345
Lake Bohio	2,786,449
Obispo gates	295,436
Culebra sections	44,378,335
Pedro Miguel locks, including excavation and dam	8,496,326
Pedro Miguel level	1,169,611
Miraflores locks, including excavation and spillway	5,720,363
Pacific level	12,366,914
Bohio dam	8,500,000
Gigante spillway	1,124,524
Channel between the marshes	1,448,076
Chagres diversion	1,929,976
Gatuncillo diversion	100,000
Panama railroad diversion	1,267,500
Total	118,618,816
Engineering, police, sanitation, and general contingencies	23,723,763
Aggregate	142,342,579

This estimate is for the completed project. A canal begun upon this plan may be opened to navigation before its final completion. If single instead of double locks be used, and the bottom width be made 100 instead of 150 ft. the cost will be reduced $26,401,364, and the estimate becomes $115,941,215.

Although the French Company for special reasons adopted the plan with a higher summit level, their engineers worked up a plan in which the level of Lake Bohio was carried completely through the Culebra cut, the high-water level being raised to elevation 67. Under this plan the supply of water for the dry months would be obtained from the upper Chagres, the Alhajuela dam being built to impound a sufficient amount. The fluctuation of the water in Lake Bohio could then be reduced to 5 ft., from 62 to 67. The dimensions adopted by this commission have been applied to a canal on these lines. The cost of the Alhajuela dam must be added as well as that of a railroad 10 miles long from the Obispo gates to the site of the dam. The estimate for completing the canal by this plan is as follows:

Colon entrance and harbor	$7,334,673
Harbor to Bohio locks, including levee	10,706,217
Bohio locks, including excavation	9,060,960
Lake Bohio	7,285,367
Obispo gates	323,805
Culebra section	53,950,078
Pedro Miguel locks, including excavation and dam	7,906,658
Pedro Miguel level	1,997,318
Miraflores lock, including excavation and spillway	5,070,879
Pacific level	12,366,914
Bohio dam	6,800,000
Gigante spillway	1,408,014
Channel between marshes	868,846
Chagres diversion	1,117,986
Gatuncillo diversion	100,000
Panama railroad diversion	1,267,500
Alhajuela dam	2,000,000
Ten miles of railroad	750,000
Total	130,315,215
Engineering, police, sanitation, and general contingencies	26,063,013
Aggregate	156,378,258

The quantities given in the above estimates are based on the present condition of the Isthmus, advantage being taken of various excavations made by the French companies.

The old Panama Canal Company and the Liquidator raised, by the sale of stock and bonds, the sum of $246,706,431.68. The securities issued to raise this money had a par value of $435,559,332.60. There had been excavated about 72,000,000 cu. yds. prior to the organization of the new company. Nearly all of the stock of the Panama Railroad had been purchased. The new company has excavated about 5,000,000 cu. yds., making the total amount excavated by the two companies 77,000,000. The amount of this work which will be of value, under the plan recommended by the Commission, has been carefully computed for the main canal line, and is found to be 36,690,649 cu. yds. Adding the excavation in the Gatuncillo diversion, which is estimated at 2,500,000 cu. yds., the quantity of excavation which will be of value in the new plan is 39,190,649 cu. yds. A temporary diversion of the Panama Railroad is also to be considered. Using the same classification of materials, and the same unit prices as in the other estimates, with the 20% for contingencies, the value of the French work already done becomes:

Canal excavation	$21,020,386
Gatuncillo diversion	1,125,000
Railroad diversion (4 miles)	300,000
	$22,445,386
Contingencies, 20%	4,489,077
	$26,934,463
Panama Railroad stock at par	7,000,000
Aggregate	$33,934,463

The value of the French work is greatly reduced by the fact that the spoil banks on the Atlantic maritime section frequently come within the limits of the enlarged canal now estimated for.

This statement does not include the value of the tools, buildings and other plant, nor of the hospital; nor does it include the value of the maps, drawings, and records, which are unusually complete, for which no accurate estimate can be made. The plant would be a matter of negotiation between its present owners and the contractors for the new work, and so is indirectly included in the cost of the canal as estimated. The offices and hospitals would be a matter of special negotiation, and form part of the sanitation expense provided by the 20% allowance on the new work.

In the letter dated Nov. 18, 1898, addressed to the President of the United States by Mr. J. Bonnardel, president of the board of directors of the Panama Canal Company, it was stated that the company's assets exceeded in value $100,000,000.

INDUSTRIAL AND COMMERCIAL VALUE OF AN ISTHMIAN CANAL.

The use that would be made of an isthmian canal by the United States and other nations, and the effects of that use upon the development of our resources and the extension of our domestic and foreign trade have been carefully investigated, and the commercial advantages derivable from the Nicaragua and Panama routes have been compared in order that every factor having a bearing upon the location of the canal might be considered. In the prosecution of this inquiry data were secured from the official statistics of our own and foreign governments, from commercial organizations and business men who were conferred with personally, and by an extensive correspondence. The final report of the Commission will contain a full discussion of the value of the canal. The following are some of the conclusions to which this investigation has led:

PRESENT TONNAGE OF AVAILABLE TRAFFIC.—To determine the amount of tonnage that would use a canal, were it now in existence, two distinct statistical investigations have been made. In one of these the exports and imports of the United States and of the leading commercial nations of Europe were studied for the purpose of ascertaining how many tons of cargo, or how much freight, those countries would now contribute to the traffic through an American interoceanic canal. The statistics and imports of all countries being given either in values or quantities, it was necessary to convert these into their tonnage equivalents. This change having been made for each commodity, it was found that 3,426,752 cargo tons of the maritime commerce of the United States during the year ending June 30, 1899, could have used the canal to advantage. During the calendar year 1898 the trade of Europe with the west coast of South and Central America and British Columbia amounted to 3,346,377 cargo tons. The sum of these two amounts, 6,773,129 cargo or freight tons, does not include any of the trade between Europe and the Orient, a part of which would have used the American canal had it been in existence. The figures, moreover, apply to the commerce of the past carried on under the conditions then prevailing.

The statistics of entrances and clearances show that the net register tonnage of the American and foreign shipping that would have passed through a canal had it existed during the year 1898-99 was 4,582,128 tons, in addition to a part of the commerce between Europe and the Orient. The opening of the American Isthmian Canal will accentuate the present tendency of traffic to follow round-the-world lines, and not less than one-fourth of the present traffic of Europe with Eastern countries may be expected to use this route. One-fourth of the vessel tonnage employed in the European-Oriental commerce during the calendar year 1898 amounted to 1,154,328 tons net, and this added to 4,582,128 gives a total of 5,736,456, the number of tons of shipping that would have used a canal had it been in existence in 1898-99.

Records of vessel movements, kept by the New Panama Canal Co., show that the commerce between the east and west coasts of the American continent, and between Europe and the American west coast would have caused an isthmian canal to be used by 3,848,577 tons net of shipping in 1899. This sum plus one-fourth of the vessel tonnage of the commerce between Europe and the East gives 5,126,890 tons net register for the traffic available in 1899. The difference between the result of the investigation made by the French company and that conducted by this Commission is 609,566 tons; however, two-fifths of this difference is accounted for by the fact that the French statisticians did not include any tonnage for the trade carried on between the eastern half of the United States and foreign Pacific countries by way of our Pacific ports. The difference between the two totals may also be partly due to their not covering identical periods. The United States statistics of entrances and clearances studied by this Commission were for the fiscal year ending June 30, 1899, whereas the French record of vessel movements was for the calendar year 1899. The similarity in the results of the two investigations is evidence of the essential accuracy of both.

PROBABLE TRAFFIC 1909 AND 1914.—The increase during the decade preceding 1899 in the tonnage of the vessels that would have used the canal was 22.55%. Upon the safe assumption that this rate of increase per decade will continue, the available canal tonnage of 1898, as calculated by the French statisticians, will have become 6,127,112 tons in 1908, and 6,922,166, or, in round numbers, 7,000,000 tons net register in 1914; that is, at the end of sixteen years. If the tonnage of the entrances and clearances of the available canal traffic of the year 1898-99, as determined by this Commission's investigation (5,736,456 tons net register), be taken as the basis of estimate, an increase of 22.55% per decade would make the figures for 1909, 7,030,027 tons, and for 1914, 7,782,240 tons net register.

NICARAGUA AND PANAMA ROUTES FOR SAILING VESSELS.—Three-fifths of the seagoing tonnage of the United States now consists of sailing vessels, and we have a larger ocean-sailing tonnage than any other country except the United Kingdom. However, sails are being displaced by steam, and the statistics of steamers and sailing vessels indicate that not more than one-sixth of our total seagoing tonnage will consist of sailing vessels in 1914. If the sailing vessel should continue to give way to the steamer after that date an isthmian canal will not be much used by sailing ships. The unmistakable tendency of commerce is to employ steam instead of sails, not only in the transportation of general or mixed freight, but also for carrying full cargoes of bulky commodities. Moreover, the canal will so increase the competitive advantages of the steamer as to render practically certain its general substitution in place of the sailing vessel for all lines of trade through an isthmian waterway.

BENEFITS TO EUROPE AND UNITED STATES COMPARED.—As compared with Europe, the United States will derive from the canal far greater benefits, both commercially and industrially. The commerce of Europe with the Pacific coast of North, Central and South America, under existing conditions, is somewhat larger than the total volume of the present traffic of the United States that may be considered tributary to the canal; but this fact does not indicate the relative advantages which the canal will possess for the trade of Europe and that of the United States. As soon as it has been opened, our trade with the west coast of South America will rapidly increase, as will also the volume of our trade with the Orient. The amount of the American commerce through the canal will quickly surpass the total amount of Europe's traffic.

An isthmian canal will strengthen the unity of the national and political interests of the United States, develop its Pacific territory, and promote the commerce and industries of the entire country. The benefits which Europe will derive from the canal will be commercial. In addition to this ours will be political and industrial. By bringing the eastern and western sections of our country into closer relations, by reducing the time and cost of transporting our western products to Europe, and by enabling the Eastern, Southern and Central States to reach the raw materials and markets of Pacific countries cheaply and expeditiously, the canal will more fully identify political and social interests and quicken the industrial activity of every section of the United States. The iron and steel, the textiles, and the other manufactures of the Eastern and Southern States, the coal from the mining regions, the cotton from the South, and the grain and forest products from many sections will flow out to foreign countries in an increasing volume, and this larger trade will be shared generally by the ports of all our seaboards—the Atlantic, the Gulf, and the Pacific. The canal will cause the competition of the United States with Europe in the countries of Western South America and the Orient to be much keener, with the result that the trade of our country will increase more rapidly than will that of our rivals. The canal will aid the United States in securing and maintaining a position of primacy in the international trade of the world.

These are the considerations which justify the expenditure by the United States of the sum required to build the canal. They may involve a low tariff of charges and be at variance with the production of a large revenue from the canal.

COMMERCIAL ADVANTAGES. NICARAGUA AND PANAMA ROUTES COMPARED.—(a) One method of showing the relative advantages which the Nicaragua and Panama routes would possess is to compare the distances by way of each of them between typical Atlantic and Pacific ports. A few distances are shown in the accompanying table, compiled with the assistance of the United States Hydrographic Office. The table applies only to the routes followed by steamers, and the length of each canal line is reckoned in nautical miles.

Comparison of Distances for Steamers by the Nicaragua and Panama Routes.

From	To San Francisco,			To Yokohama via Honolulu,			To Shanghai via Honolulu			To Guayaquil		
	Via Nicaragua, miles.	Via Panama, miles.	Saved via Nicaragua, miles.	Via Nicaragua, miles.	Via Panama, miles.	Saved via Nicaragua, miles.	Via Nicaragua, miles.	Via Panama, miles.	Saved via Nicaragua, miles.	Via Nicaragua, miles.	Via Panama, miles.	Saved via Panama, miles.
New York	4,922	5,299	377	9,832	10,087	255	10,752	11,007	255	3,247	2,864	383
Liverpool	7,652	8,038	386	12,562	12,826	264	13,482	13,746	264	5,977	5,603	374
New Orleans	4,119	4,698	579	9,029	9,486	457	9,949	10,406	457	2,444	2,263	181

Between New York and San Francisco, the Nicaragua Canal route would be 377 nautical miles shorter than the Panama route. Between New Orleans and San Francisco 579 miles would be saved, and, in general, the distances between the Atlantic and Pacific ports of the United States are less by way of Nicaragua. Between our east coast and Yokohama and Shanghai the Nicaragua route is somewhat shorter, but for the trade of our eastern ports with the west coast of South America the Panama route is not so long as the Nicaragua.

(b) A part of the saving in distance effected by using a Nicaragua canal instead of one at Panama would be offset by the longer time of transit at Nicaragua. An average steamer would require 12 hours to make the passage through the Panama Canal, and 33 through one across Nicaragua. For a 10-knot steamer this difference of 21 hours would be equivalent to 210 knots difference in distance, and for a 13-knot steamer, the difference in time of transit would be equivalent to 273 knots.

(c) The Nicaragua route would be the more favorable one for sailing vessels because of the uncertain winds in the bay of Panama. It would not be impossible for sailing vessels to use the Panama Canal, but for average voyages between the two seaboards of the United States, a sailing vessel would require about nine days additional time to make the passage by way of the Panama Canal. However, neither route would be much used by sailing vessels, because of their inability to compete with steamers. They would certainly not be able to compete with steamers, both using the Panama Canal.

(d) For the promotion of the domestic trade of the United States, the Nicaragua route would possess advantages over the Panama route, because the distance between our two seaboards is less. For our trade with Japan, China, the Philippines and Australia the advantages of the two routes are nearly equal, the distance by way of the Nicaragua route being slightly less. For our trade with South America the Panama route is shorter and more direct.

(e) The industrial changes which the Nicaragua Canal would produce in the countries through which it will pass would be great. Nicaragua and Costa Rica comprise a region capable of producing a large amount of tropical products for which there is a demand in Europe and the United States. A canal across their territory would give a great impetus to their economic development.

RIGHTS, PRIVILEGES AND FRANCHISES.

The Commission finds that the concessions granted by Nicaragua to the Maritime Canal Co. and the Interoceanic Canal Co. have been forfeited, and if these forfeitures are final these concessions do not stand in the way of the grant to the United States by Nicaragua of the consent

and authority necessary for the construction of a canal upon this route.

At Panama, however, the concession under which the present French company is working expires in 99 years from Oct. 31, 1910, and this concession by its terms cannot be transferred or mortgaged to any nation or foreign government. Further, at the expiration of the concession the canal with all its appurtenances becomes the property of the Colombian Government. The Government is also entitled to an annual payment ranging from $250,000 a year up to 8% of the gross receipts. The charter of the company further provides that all the plant for the canal's construction must be made in France from French materials. As the Commission well says, a new arrangement is necessary if the United States is to undertake such a work. No proposition has been made by the canal company, however, under which a new arrangement would be possible.

FINAL COMPARISON OF THE TWO ROUTES.

I. The estimated cost of building the Nicaragua Canal is about $58,000,000 more than that of completing the Panama Canal, leaving out the cost of acquiring the latter property. This measures the difference in the magnitude of the obstacles to be overcome in the actual construction of the two canals, and covers all physical considerations such as the greater or less height of dams, the greater or less depth of cuts, the presence or absence of natural harbors, the presence or absence of a railroad, the exemption from or liability to disease, and the amount of work remaining to be done.

The New Panama Canal Company has shown no disposition to sell its property to the United States. Should that company be able and willing to sell, there is reason to believe that the price would not be such as would make the total cost to the United States less than that of the Nicaragua Canal.

II. The Panama Canal, after completion, would be shorter, have fewer locks and less curvature than the Nicaragua Canal. The measure of these advantages is the time required for a vessel to pass through, which is estimated for an average ship at twelve hours for Panama and thirty-three hours for Nicaragua.

On the other hand, the distance from San Francisco to New York is 377 miles, to New Orleans 579 miles, and to Liverpool 386 miles greater via Panama than via Nicaragua. The time required to pass over these distances being greater than the difference in the time of transit through the canals, the Nicaragua line, after completion, would be somewhat the more advantageous of the two to the United States, notwithstanding the greater cost of maintaining the longer canal.

III. The Government of Colombia, in which lies the Panama Canal, has granted an exclusive concession, which still has many years to run. It is not free to grant the necessary rights to the United States, except upon condition that an agreement be reached with the New Panama Canal Company. The Commission believes that such agreement is impracticable. So far as can be ascertained, the company is not willing to sell its franchise, but it will allow the United States to become the owner of part of its stock. The Commission considers such an arrangement inadmissible.

The governments of Nicaragua and Costa Rica, on the other hand, are untrammeled by concessions and are free to grant to the United States such privileges as may be mutually agreed upon.

CONCLUSION.

In view of all the facts, and particularly in view of all the difficulties of obtaining the necessary rights, privileges and franchises on the Panama route, and assuming that Nicaragua and Costa Rica recognize the value of the canal to themselves and are prepared to grant concessions on terms which are reasonable and acceptable to the United States, the Commission is of the opinion that "the most practicable and feasible route for" an isthmian canal to be "under the control, management and ownership of the United States" is that known as the Nicaragua route.

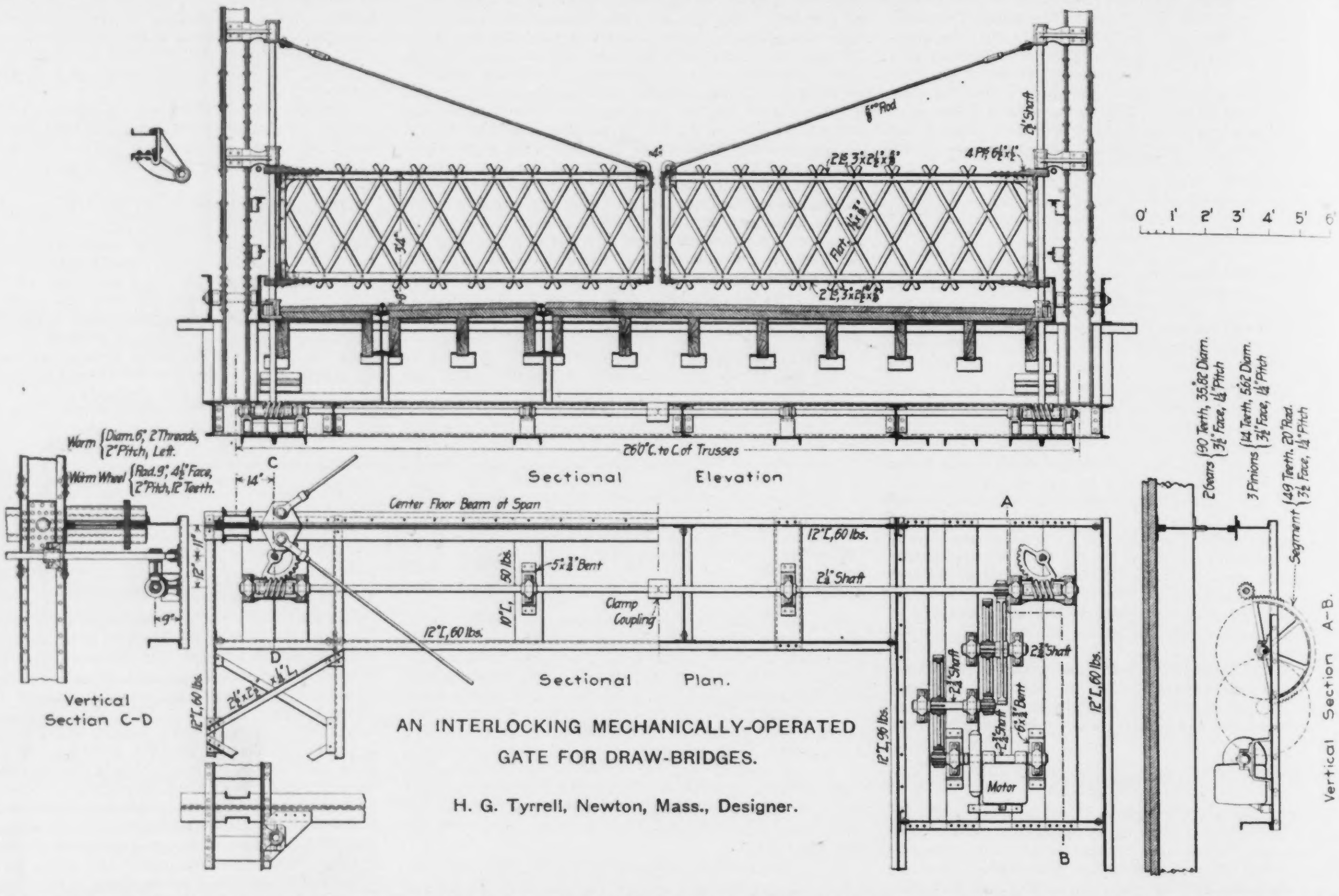
J. G. Walker, Rear-Admiral, United States Navy, President of the Commission; Samuel Pasco, Alfred Noble, Geo. S. Morison, Peter C. Hains, Colonel, United States Corps of Engineers; Wm. H. Burr, O. H. Ernst, Lieutenant-Colonel, United States Corps of Engineers; Lewis M. Haupt, Emory R. Johnson.

AN INTERLOCKING MECHANICALLY OPERATED DRAW BRIDGE GATE.

By H. G. Tyrrell.*

The frequency with which serious accidents occur at open draw bridges has prompted the writer to design a mechanically operated gate which he believes to furnish an absolute safeguard against disasters of this sort in all but extraordinary cases. The essential idea of this design is that the bridge and the gate cannot be open at the same time. The first cost of these gates is of course high, in comparison with the first cost of the ordinary style of hand-operated wooden gates, but they dispense entirely with the services of a gateman, and for this reason will prove more economical in the long run.

The accompanying drawings show a pair of gates applied to a bridge with approach spans at either end, and having a 26-ft. roadway and no sidewalks. The design can, however, be modified to suit any width of bridge, either with or without sidewalks. As will be seen, the gates are keyed to vertical shafts, which are shown turning in boxes fastened to the web posts of the fixed span. At the foot of these shafts are toothed segments worked by worms, which lock the gates in any position. These worms turn in oil baths, as shown. The worm shaft is connected by a system of reducing gears with the motor. In this system of gears is included a half-gear, which insures a movement of 90° only to the gates, and at the same time gives the operator a few seconds leeway in shutting off his power from the gate motor. Power is supplied by a General Electric 3-HP. enclosed motor, shown in the lower right-hand corner of the drawing, and this receives its current from wires on the draw span, through contact plates. When the gates are closed and the draw span is swung open, the electric connection is broken and the gates cannot be moved. Hence, the gates are controlled entirely by the operator on the draw span. The service of one man only is required on the bridge at any one time.



AN INTERLOCKING MECHANICALLY-OPERATED GATE FOR DRAW-BRIDGES.

H. G. Tyrrell, Newton, Mass., Designer.

A bridge equipped with these gates can be opened and closed very quickly, since no time is lost in walking to and from the gates, as in the case of wooden gates operated by hand. The gates are always locked in every position, either open or closed. As an extra precaution they may be placed say 100 ft. from the draw span. Then, should a car or train break through them, they would certainly come to a standstill before reaching open water. An estimate, based on the accompanying plan, and including both ends of the bridge, is as follows:

Weight of gates.............	2,100 lbs.
" of machinery.........	5,600 "
" of machinery support..5,200 "	
12,900 lbs. at 5 cts. =	$645
Two motors, 3 HP. =	300
Total cost...........	$945

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