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WORLD'S LARGEST REINFORCED CONCRETE ARCH SPAN

UNIQUE DESIGN AND CONSTRUCTION METHODS NEW TO WESTERN ENGINEERS EXEMPLIFIED IN THE LANGWIES VIADUCT, SWITZERLAND.

By ALBERT M. WOLF, C.E.

THE construction methods used in the building of the Langwies viaduct in Switzerland in 1912-14, whose main arch span is the largest in the world, when span, rise and load to be carried are considered, are unique, and present great possibilities for adaptation to American conditions.

The viaduct was built in connection with the new Chur-Arosa electric railway to accommodate Swiss resort travel to Arosa, which is noted as a health and winter sport resort. Previously, this place could be reached only by stage, after a slow journey of six hours over narrow and steep roads, while now only 1½ hours will be consumed in making the journey. Increasing business demanded a better mode of travel and the electric road was built by the hotel interests to meet the demand.

The new line has a length of 16.15 miles with a rise of 3,650 ft. in an almost unbroken 6% grade. The construction involved some very heavy and expensive work, including 19 tunnels, with a total length of 7,710 ft., 27 large stone bridges, 3 steel bridges and two large concrete arch viaducts, one having an arch of 282-ft. span, and the other, the Langwies viaduct, an arch of 315 ft. clear span. From Chur to Langwies the railroad runs along the right bank of the Plessur River; at the latter point the river is crossed close to its confluence with the Sapüner Brook at an elevation of 4,330 ft. above sea level by the viaduct.

General Description.—The entire viaduct, 935 ft. long, is of reinforced concrete construction, consisting of a 314-ft. 11½-in. arch span with a rise of 134 ft. 3 in. and four continuous girder approach spans at each end, carried on high concrete bents 52 ft. 6 in. apart. At one end are three additional girder spans separated from the main structure, for esthetic reasons, by a wide abutment pier. Two of these latter are of 42 ft. 8 in. clear span and one of 32 ft. 9½ in. clear span.

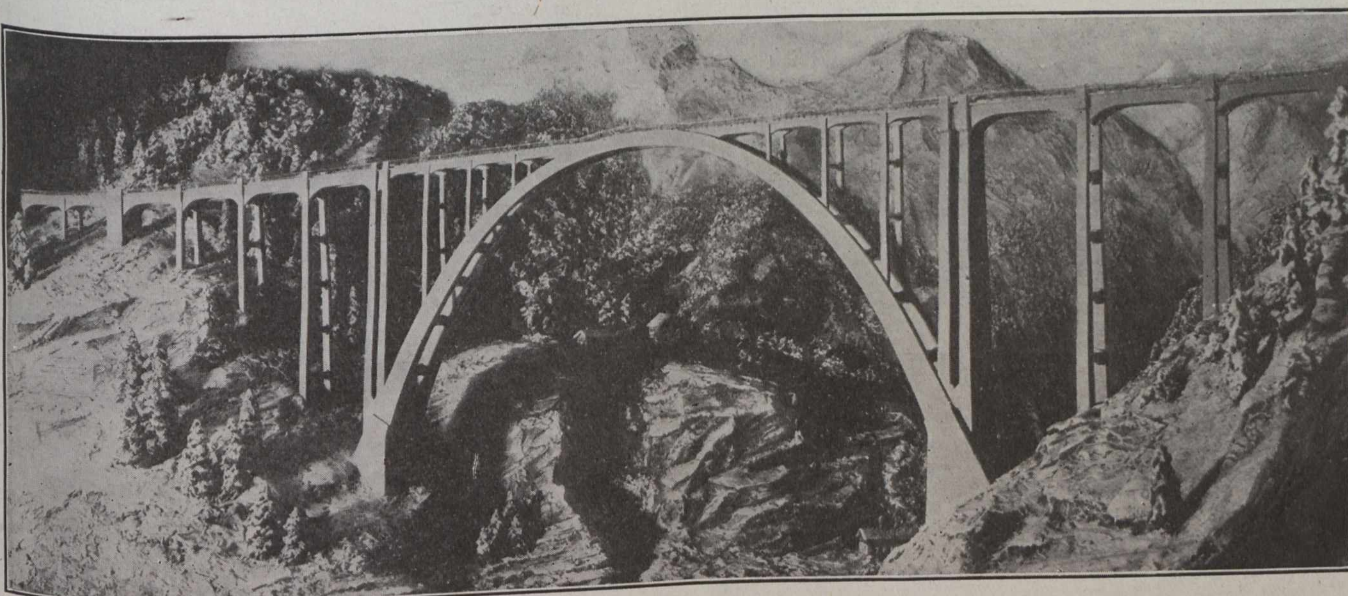


Fig. 1.—The Langwies Viaduct, Chur-Arosa Railway, Switzerland.

The arch is composed of two reinforced concrete ribs with fixed ends, braced at intervals by transverse struts, with an overall width at the crown of 16 ft. 6½ in. These ribs are 7 ft. deep and 3 ft. 3½ in. wide at the crown, the depth and width being increased from crown to spring to keep the thrust line within the middle third of the rib and give added lateral stiffness. The roadway deck over the arch is carried by continuous girders supported on double column bents of reinforced concrete resting on the arch ribs and spaced about 29 ft. 6 in. centres. The general appearance of the structure is shown in Figs. 1 and 2.

Comparison With Other Concrete Arches.—The developments made in the last decade in the design and construction of large concrete arches have been toward the gradual increase in the main dimensions of such structures as will be noted in the following historical outline. In 1906 the largest arch span was the famous Walnut Lane arch at Philadelphia, Pa., with a clear span of 232 ft. In 1909 the Stein-Teufen arch in Switzerland, with a span of 259 ft., was built. The year 1911 saw two long span arches completed, *viz.*, the Risorgimento arch over the Tiber at Rome, with a clear span of 328 ft. 1 in., and a rise of about 32 ft., and the Auckland, New Zealand, arch, with a clear span of 320 ft. and a rise of 84 ft. The Larimer Avenue arch, Pittsburgh, Pa., with a clear span of 300 ft. 5 in. and a rise of 67 ft., was completed in 1912. The Langwies arch has a clear span of 314 ft. 11½ in., a rise of 134 ft. 3 in., and a crown height above the valley of about 203 ft. Although about 13 ft. shorter than that of the Risorgimento arch and 5 ft. shorter than that of the Auckland arch, the rise exceeds that of the former by about 102 ft. and that of the latter by about 50 ft. The only structure with a rise anywhere near as great as this is the Monroe Street arch at Spokane, Wash., with a span of 281 ft. and a rise of 113 ft. The Langwies arch is designed for a narrow gauge electric railway, while the others are for heavy highway loading only. As far as esthetic design is concerned, the Langwies arch outranks by far the two arches just mentioned, and, although not as artistic as the Larimer Avenue bridge, is an excellent example of a plain but graceful design.

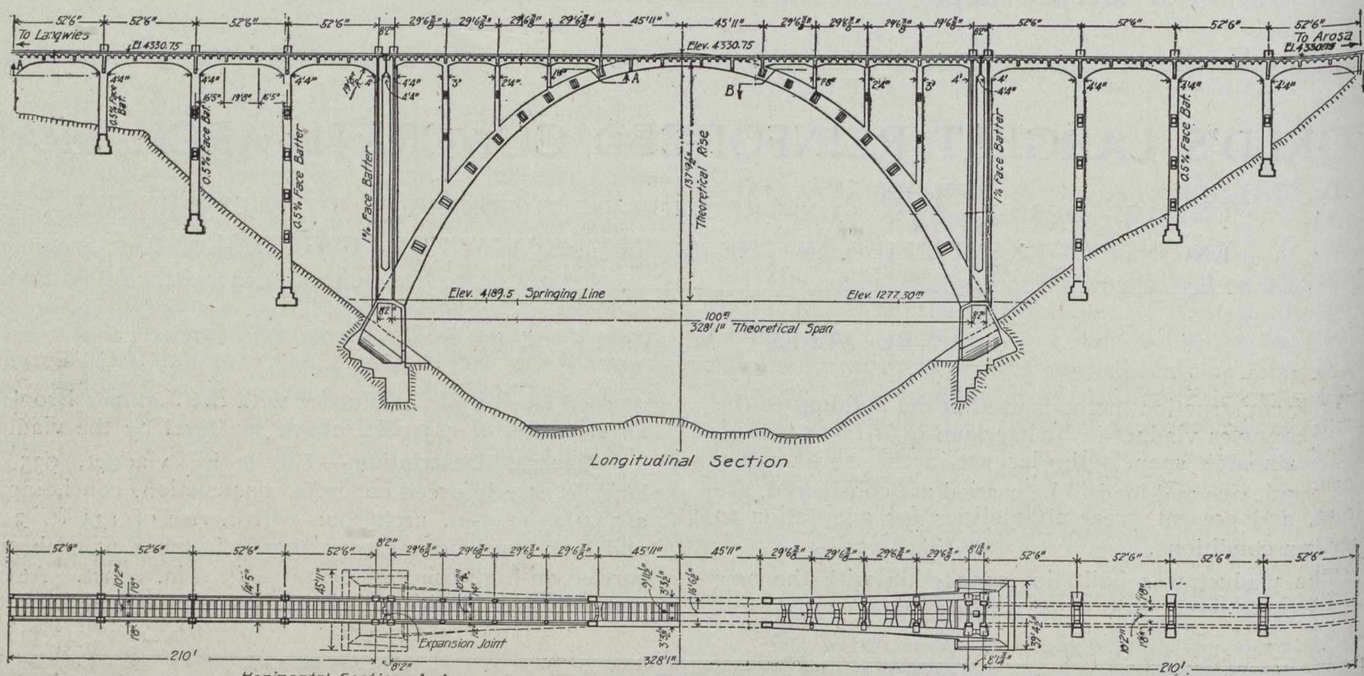


Fig. 2.—Plan and Sections, Langwies Viaduct.

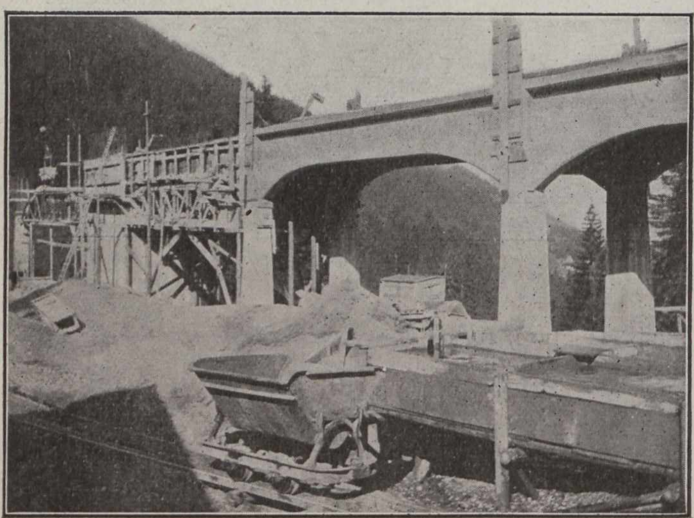


Fig. 3.—Long Span Continuous Girders of Approach.

Design Requirements and Loadings.—Lack of satisfactory building stones, and difficult and rough roads precluded the use of masonry arches or heavy steel girder bridges, while the abundance of good gravel and sand at the site led to the selection of a reinforced concrete viaduct as the most suitable type. At first the Swiss department of railways objected very strenuously to this plan, on the ground that the dimensions of the bridge were too great for safe construction of reinforced concrete. The contractors succeeded, however, in overcoming all the objections and in obtaining the consent of the authorities for the building of the structure, work on which began in the summer of 1912.

A long-span arch was the logical solution of the problem of bridging the deep mountain gorge and for economical reasons a twin ribbed arch was used. On account of the very favorable foundation conditions the main arch was proportioned and designed as a fixed arch in accordance with the method of the elastic theory, the temperature and rib shortening stresses being minimized by the great rise of the arch. The structure as designed, required no reinforcement for dead and live load stresses, being so proportioned as to keep the line of pressure well within the middle third of the ribs. To provide for such tensile stresses as might arise to temperature changes and rib shortening alone or combined with the dead and live load stresses, steel reinforcement was used in both extrados and intrados of the arch ribs. For the approach spans continuous girders were used because the great height of the roadway above the ground made a construction free from horizontal thrust very desirable for this portion of the viaduct.

On account of the high altitude—4,330 ft. above sea level—the structure is subjected to very great variations in temperature and special provision had to be made for expansion. The roadway over the arch was therefore separated from the approach spans by the use of double piers over the arch abutments with an expansion joint between. The high intermediate piers connected rigidly to the girders were designed so as to be sufficiently elastic to allow for longitudinal expansion of the deck without overstressing them.

The main objects to be fulfilled in the design and construction of this bridge were: (1) To keep the actual stresses as low as possible and at the same time (2) to save as much material as possible. On account of the relatively small live load, as compared with the dead load, these conditions could readily be complied with by the use of an arch composed of two ribs instead of a solid barrel arch.

By designing the deck of the approach spans as a series of continuous girders, transmitting the wind stresses directly to the end abutments and to the large double piers over the arch abutments, the approach piers could be consistently made of light construction consisting of two main posts of reinforced concrete tied together by struts of the same material. By this method of design, heavy stresses were transmitted to the double piers, and it was therefore necessary to connect each pier to these posts with a solid transverse wall.

In order to secure greater stability, against wind pressure and the buckling action of the arch acting as a column, the exterior faces of the arch ribs were given a 4% batter or flare from crown to the abutments. The inside faces of the ribs were also given a batter of 2½% toward the abutment, in order to secure the additional required strength toward the springing.

Live Loads.—The live load used for the design of the viaduct consisted of one train of two electric locomotives each of 65 tons maximum weight, followed by an unlimited number of freight cars.

For designing the longitudinal girders over arch and approaches and the roadway slabs an additional live load was added in accordance with the formula $\frac{15-l}{100}$, in which l is the span in meters. Temperature stresses due to a range of ± 27° F. were considered in design, also shrinkage stresses due to a further decrease of 36° F. The allowance made for horizontal traction or braking loads was equivalent to one-seventh of all wheel loads. A wind load of 20 lb. per sq. ft. for loaded structure and 30 lb. per sq. ft. for the structure alone, was considered in design. The area exposed to wind was considered as follows: Face of girders, twice the area of front face of columns, one and one-half times the front face of double piers, and for trains a surface 10 ft. high, with the pressure acting at 6½ ft. above the rail.

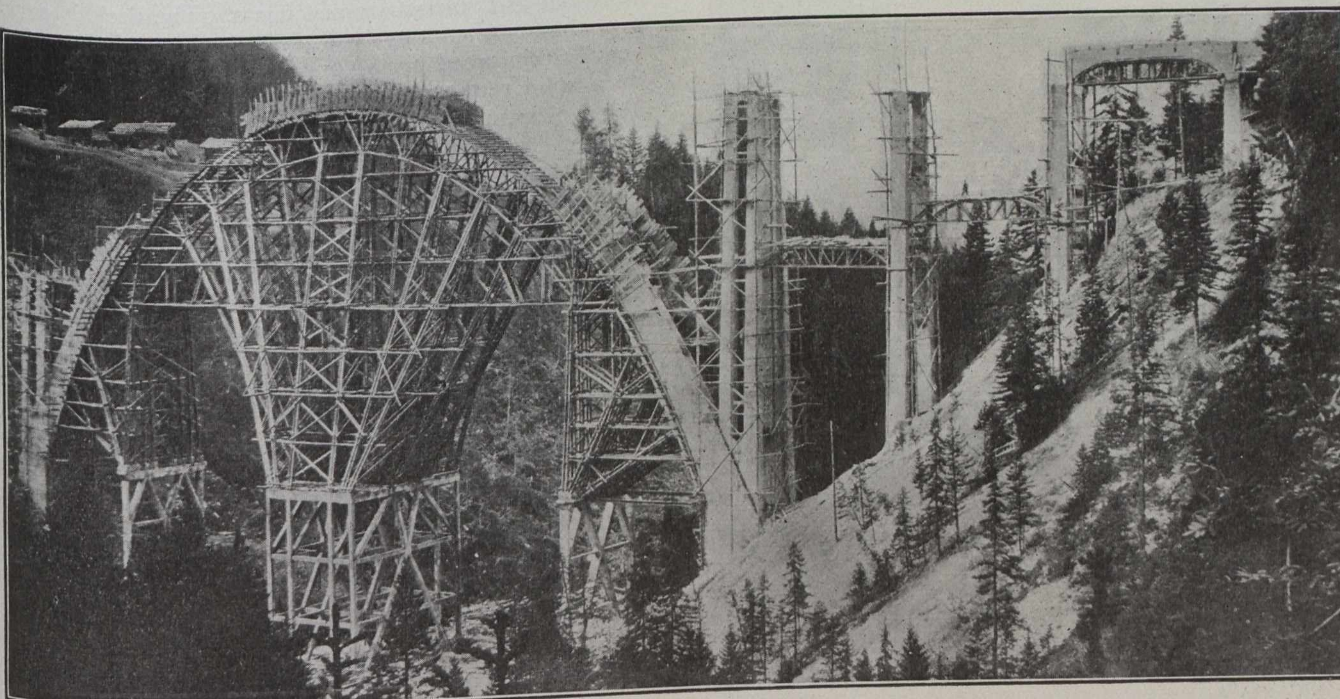


Fig. 4.—Completed Centering for Arch Span.

Unit Stresses.—The allowable unit stresses used in design were for dead and most unfavorable conditional live load 495 lb. per sq. in. compression in concrete and 14,200 lb. per sq. in. in steel, while for combined stresses due to dead and live loads shrinkage, temperature traction and wind the compression in concrete allowed was 639 lb. per sq. in. and the stress in steel 17,040 lb. per sq. in. The allowable shear in concrete was 57 lb. per sq. in. The modulus of elasticity of concrete was taken as 2,800,000 lb. per sq. in. and the ratio Es/Ec as 15. All concrete was sampled and tested daily and when poured as a plastic or wet mass was required to have a strength of 2,556 lb. per sq. in. at 28 days, and 3,550 lb. per sq. in. for dry mixed or slightly moist concrete.

In the arches and columns and those parts of the structure where the stresses are mainly compressive, the stresses were computed by the Ritter method. For members subjected to bending, the compressive and tensile stresses were computed by Christoph's method, due allowance being made for the strength of concrete in tension due to bending, which is in accordance with the Swiss regulations. The shearing stresses were very carefully analyzed, and wherever they exceeded 57 lb. per sq. in. stirrups were used to take up the entire stress. This condition necessitated the use of a great amount of steel in the form of stirrups.

Arch Ribs.—The two main arch ribs have a theoretical span of 328 ft. 1 in., a clear span of 314 ft. 11½ in., and a theoretical rise of 137 ft. 9½ in. The ribs are about 7 ft. deep and 3 ft. 3½ in. wide at the crown, the depth being increased toward the springing so as to keep the line of thrust well within the middle third. The width of ribs is increased from crown to spring in accordance with the batters previously given. The ribs are reinforced

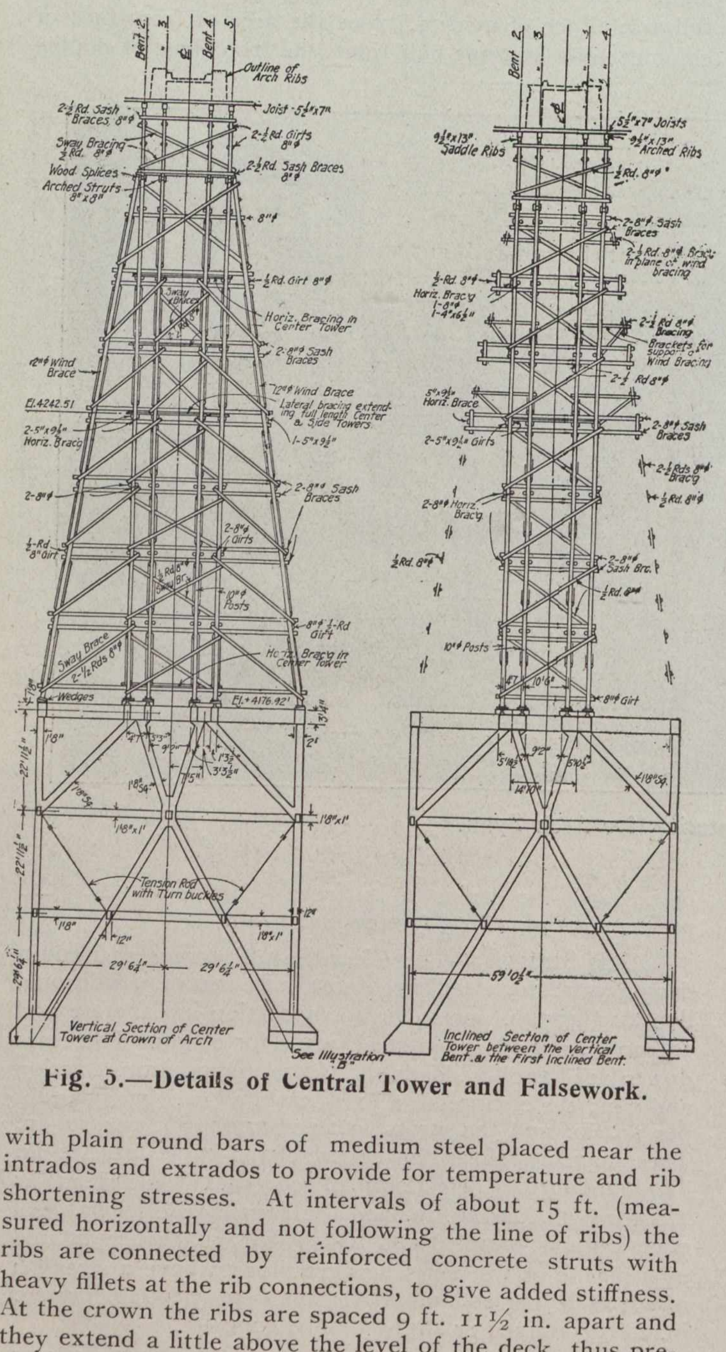


Fig. 5.—Details of Central Tower and Falsework.

with plain round bars of medium steel placed near the intrados and extrados to provide for temperature and rib shortening stresses. At intervals of about 15 ft. (measured horizontally and not following the line of ribs) the ribs are connected by reinforced concrete struts with heavy fillets at the rib connections, to give added stiffness. At the crown the ribs are spaced 9 ft. 11½ in. apart and they extend a little above the level of the deck, thus preserving the outline of the arch ribs very effectively. (See Fig. 1.)

Arch Abutments.—The arch abutments, consisting of two pyramoidal blocks of plain concrete one under each rib connected by reinforced slabs at bottom and front, are carried down to solid rock, with the bottoms stepped or serrated to give added stability, and to prevent sliding, and at the same time to follow closely the line of rock surface. The abutment faces are vertical while the backs are sloped in a line parallel to the thrust line in the arch ribs at the springing line. The left abutment (See Fig. 2) is 45 ft. 11 in. wide, while the right abutment is only 39 ft. 4½ in. wide, the difference in width being due to the difference in character of the foundations encountered on the two sides of the valley.

Arch Span Roadway Deck.—The roadway deck over the arch span (see Fig. 2) is carried by four pairs of posts, at each side of the crown, spaced 29 ft. 6 in. centres. These posts or columns are of reinforced concrete securely dowelled to the arch ribs and varying in width from 1 ft. 8 in. for the ones near the crown to 4 ft. 4 in. for those over the abutments. The two intermediate pairs are tied together by transverse struts (see Fig. 1) to make the posts act as two-post framed bents. The deck is carried over the abutments by twin piers, each consisting of two heavily reinforced posts connected for their entire height by a solid reinforced concrete wall, instead of struts. These piers, 4 ft. 4 in. apart, are connected at the bottom near where they intersect the arch ribs and are separated at the top by an expansion joint. One acts as the end pier for the roadway girders over the arch and the other as the end pier of the approach spans and, as previously noted, they take up all the expansion of the deck through their elastic deformation.

The deck construction consists of a thin reinforced concrete slab carried on cross-beams, spaced about 4 ft. 2 in. centres, supported by longitudinal spandrel girders continuous over the spandrel columns. The spandrel girders are anchored to the arch ribs near the crown and rigidly connected with the tall piers over the abutments, which provide for the expansion of the deck by their elasticity. The cross-beams at the spandrel columns are of greater depth than the others to provide extra lateral stiffness required by their action as part of the framed spandrel bents. Haunches and heavy fillets are provided where slabs and girders framed into their supports to care for the compression resulting from the continuous action developed.

The roadway is 13 ft. 1½ in. wide between railings, with a sidewalk space 2 ft. 4 in. wide on each side of curbs. The deck slab is waterproofed and covered with a layer of sand upon which is placed a layer of crushed stone 1 ft. deep, to serve as a track ballast.

Approach Spans.—The construction of superstructure of approaches is the same at that just described. The longitudinal girders were concreted first with reinforcement for cross-beams in place and anchored into the side girders. The floor reinforcement was then placed and the slab concreted. The cross-beams are reinforced with bent-up bars, stirrups and compression bars in top, the slab steel being bent up over these, to form negative reinforcement at right angles to the beams.

The main girders of the approach spans are of much longer span than those over the arch, *viz.*, 52 ft. 6 in. centre to centre or 48 ft. 2 in. clear. These girders are 5 ft. 3 in. deep and 1 ft. 7¾ in. wide. They are designed as continuous beams with a variable moment of inertia, with rigidly fixed ends at the cellular abutments and elastically framed connections at the intermediate piers and the double piers over abutments. The ends of girders are curved to a radius of 19 ft. 8 in. for a portion 16 ft. 5 in. out from the centre lines of columns or piers with a tangent portion 19 ft. 8 in. long, between. This gives them a very pleasing appearance and adds greatly to their strength. Fig. 3 shows two of the completed approach girder spans and centering in place for two others.

The approach piers each consist of two posts 4 ft. 4 in. wide with battered faces, founded on stepped footings carried down to rock. The posts or columns of the higher piers are tied together at intervals by cross-struts with heavy fillets at ends. The columns of the approach piers and the double piers over the abutments are carried up above the deck as projecting pilasters, thereby defining more clearly the approaches from the main arch construction. The three additional approach spans at the Langwies end are not shown in Fig. 2; their construction, however, is the same as that of the other spans, but they are designed to act independently of the others, being separated from the main approach by a wide abutment pier.

The entire structure has an appearance of extreme lightness in spite of its great size, due to slender proportions of the high approach spans and the arch spandrel system. The architectural treatment of the viaduct is along simple but impressive lines with very little embellishment in any of the parts.

General Construction Features.—Actual work on the viaduct was begun in August, 1912, but the arch centering was not started until the spring of 1913. The arch ribs and the approach at the Langwies end of the bridge were completed before stopping work for the winter, in November, 1913. (See Fig. 7.) The spandrel construction over the arch and the approaches at the Arosa end were completed in the next spring, the entire work having been finished in July, 1914. The excavation for foundations was carried down through compact moraine and glacial drift deposits which were very difficult to penetrate.

General Details of Falsework and Centering for Arch Ribs.—The centering used to support the arch ribs during construction was one of extraordinary design and entirely different from anything ever used in America for such work, not because it is not adapted to use on this side but rather because engineers are in general slow to adopt radically different methods of construction from those ordinarily used.

The centering used consisted of a central fan-like wooden falsework of radial ribs, securely braced both diagonally and horizontally and supported on a central reinforced concrete tower consisting of four bents connected by rigid framing and two single reinforced concrete bents, one near each abutment, supporting wooden falsework in the shape of a half fan with ribs radiating toward the abutments. The wooden timbers used were round and half-round, unhewn material, the timber on the site being cheap, of good quality and obtainable in long lengths. The general design and appearance of the centering is shown in Fig. 4, which shows the centering completed and the arch ribs being concreted.

Concrete has been put to a great number of uses in America where the industry has grown with enormous strides, but there are no instances on record where such large concrete structures have been built for temporary bridge construction purposes. Where the conditions are somewhat the same as at the Langwies bridge, as cited below, there is no reason why temporary towers of concrete could not be used to economical advantage, consequently there is much of interest to be found in the construction details.

In spite of the fact that timber was plentiful on the site, reinforced concrete towers designed as latticed bents were adopted as the most economical for the lower part of the centering for the following reasons:

(1) On account of the great danger of flood to which the location is subjected during the melting of the snow, situated as it is at the juncture of two rapid streams which often carry enormous quantities of water and driftwood, boulders, etc., it was necessary to restrict the waterway as little as possible. For this reason it was impossible to use vertical bents for the falsework and the tower system had to be used. Wooden towers would not have been as safe as the adopted concrete towers and would have reduced the waterway considerably more.

(2) Even if wooden towers had been used to support the centering, the foundations would necessarily have had to be of concrete, as the driving of piles through the moraine deposits of gravel and large boulders was absolutely impossible.

(3) It was desired to reduce the vertical deformation (compression) of the centering during pouring of the arch ring to a minimum. This could be obtained much better by the use of reinforced concrete towers than by using wooden towers. That the adopted design was a success in this particular is witnessed by the fact that after the arch ribs were completed a total settlement of a trifle less than ¾ in. was observed in the centering.

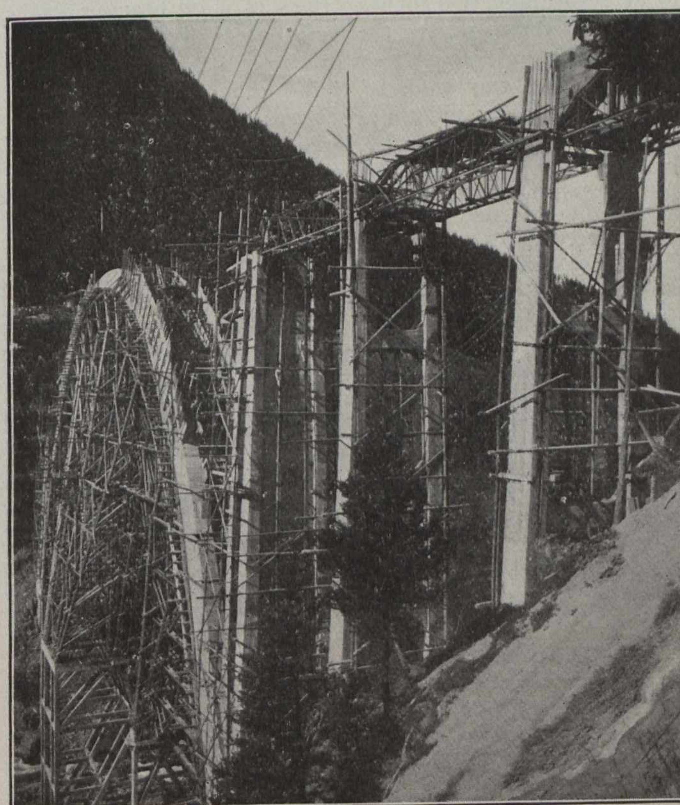


Fig. 6.—End View of Falsework, Showing Transverse Bracing—Approach Span Piers in Foreground.

Central Tower Framing.—The three-story tower carrying the central portion of the arch centering, consisted of four reinforced concrete bents, 77 ft. high and 60 ft. 8 in. wide resting on concrete footings, framed together with horizontal concrete ties. The two middle bents were spaced about 20 ft. apart with the outer bents about 10 ft. beyond, the two main vertical bents of timber falsework resting directly over the former, while the radially inclined timber bents were carried on beams between the intermediate and outer concrete bents.

The concrete bents were designed as stiff latticed frames, with intermediate members set on the diagonal so as to shorten the span of top chord or sill, and transmit the load as directly as possible to the vertical members and footings. In addition to the concrete members, two diagonal, steel tie-rods with turnbuckles were placed in the second story of each bent to balance the thrust produced on the outer vertical by the outer diagonals in the top story. The middle bents were tied with double diagonal rod bracing at each intersection in each story in addition to the horizontal concrete ties. The details of the concrete tower and the timber falsework above are shown in Fig. 5.

The timber falsework or centering carried on this concrete tower was made up of two vertical bents and four radially inclined bents at each side. (See Fig. 4.) The two vertical bents and the two intermediate inclined bents on each side were made up of four lines of struts parallel to a vertical plane passed through the centre line of structure and two inclined lines of wind bracing struts outside of these to give the bents lateral stability; on the outer and inner inclined bents this bracing is omitted. Each of these lines was made of round unhewn timbers bolted together in pairs and they were securely tied together in bents with double lines of horizontal and diagonal sway bracing timbers with the various bents tied together longitudinally in the same manner. In order to allow the

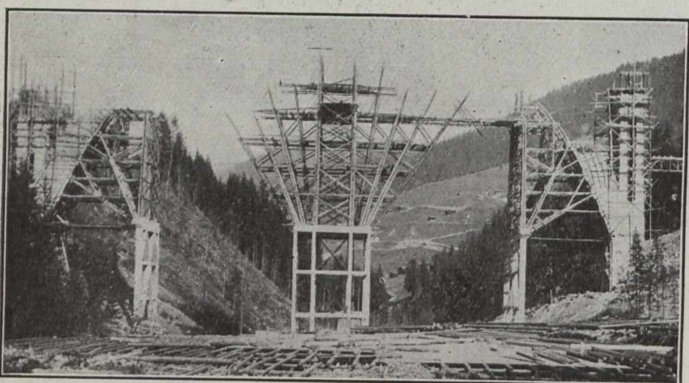


Fig. 7.—View of Falsework Under Construction, Showing Side Falsework Bents.

raising of centres if necessary and to facilitate striking them, all bents were blocked up on the tower on hardwood wedges.

Near the top, the bents are connected by lines of arched struts following very closely the line of the arch rings. At this line the bents branch out into three sets of struts, one following the line of bent and the other two set diagonally and capped with lines of saddle ribs, thus forming an arched truss to carry the decking. Upon the saddle ribs longitudinal timbers, in short lengths cut to the curve of arch ring, were laid and upon these transverse joists to carry the longitudinal lagging for soffit of arch ribs, also the side forms. Fig. 6 shows these details very clearly.

The height of this falsework above the tower was 133 ft., making the total height of centering over 200 ft., which no doubt makes this one of the highest centerings ever used for arch construction.

Side Towers.—The side towers or bents near abutments consisted of single latticed concrete bents supporting one vertical and two inclined bents of timber falsework and tied to the arch abutments by steel I-beams to brace them longitudinally and take up the thrust of the inclined timber bents. (See Fig. 7.)

The framing of the falsework over side towers is similar to that just described except that six lines of posts of struts were used in each bent instead of four. In addition to these, inclined wind bracing struts were framed to the vertical and first inclined bent. The side falsework was tied to the central portion near the top of the former by a continuous set of horizontal and diagonal bracing. The detail framing of concrete bent and timber work is shown in Fig. 8. Each longitudinal line of falsework was laid out, marked and assembled complete on a large platform in the valley close to the arch before erecting. (See Fig. 7.)

Centering for Approaches.—The approach span piers and also the columns supporting roadway deck over arch

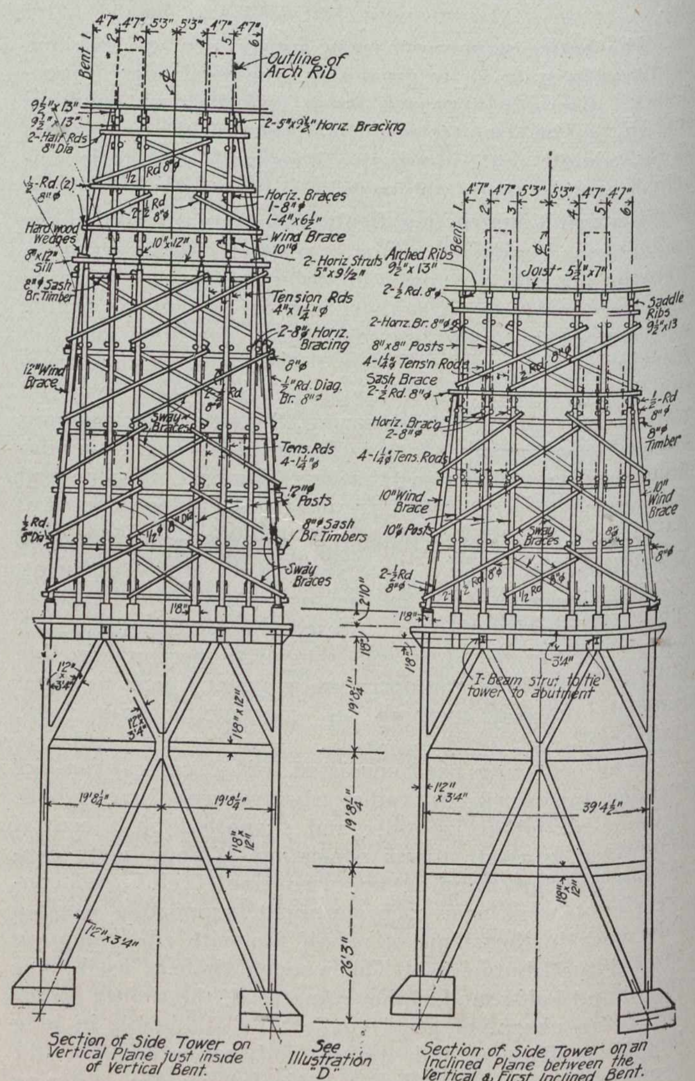


Fig. 8.—Details of Side Towers and Timber Falsework.

were built up in forms partially self supporting, the top portion being held in line by a light framework of round timbers built around the piers, while the bottom was anchored to the concrete previously poured.

The forms for the continuous girders and floor beams and slabs forming the deck were carried on steel trusses connected in pairs by rigid steel bracing. The top chords of trusses were broken so as to conform very nearly with the desired outline of girder soffits and one pair placed under each girder. During construction of the piers the trusses were raised in various stages, by means of block and tackle, between piers to serve as working or storage platforms. In Fig. 3 the centering trusses for two spans are shown in place and forms being constructed thereon and two other sets being raised into position. The approach spans at one end were built first and the next season the same trusses were used in the construction of the approaches at the other end.

Methods of Concreting.—The distribution of concrete to various parts of such a high structure as this, was a problem not ordinarily met with and did not allow much choice as to selection of plant. About the only way that concrete could be distributed with equal facility in the gorge when concreting abutments, or on the deck of structure and the various intermediate points was by buckets operated on a cableway, and this method was accordingly adopted.

A concrete mixing plant and machinery necessary to operate the cableway were installed on one side of the gorge, and a tower to support the cableway on the other side. Electrical power was used to operate all machinery. Supplies of sand and gravel of good quality were plentiful at the site and were easily and cheaply obtained. In fact, this was one of the main reasons for building a concrete arch instead of one of stone or steel.

The concrete was mixed rather dry and after being transported to the desired point in the bucket conveyer was thoroughly rammed and tamped into place. After abutments had been concreted the tall double concrete piers over the abutments to support the roadway girders and the lower portion of the arch ribs at each side were concreted. (See Fig. 7.) In the meantime the main centering was being erected and when completed a large section of the ribs at the crown was placed simultaneous with additional sections of the haunches, in order to balance the load on the centering and avoid the possibility of dangerous deformations or movements due to unequal loading. (See Fig. 6.) After this, the work was carried on in equal sections on each side of crown to meet the side section at predetermined keyways where the ribs were keyed together. On account of the sharp curvature of the ribs, top forms had to be used on most of the haunch sections to hold the fresh concrete in place, these forms being set as concreting progressed and not previous to the starting of concrete work. The arch rib reinforcement, consisting mainly of layers of plain round bars near both extrados and intrados, was placed in sections as concreting progressed, with all bars lapped at splices a sufficient distance to develop their strength in bond. The high piers supporting the approach roadway girders were poured in sections of considerable height and the columns on the arch were concreted before the arch centres were removed; the girders, however, were not poured until the centres were struck and the arch had assumed its deformation due to its own weight. The spandrel columns were built up from pedestals formed at the time of pouring arch ribs, stub bars to lap with the vertical bars in columns being embedded in these pedestals.

After the forms for roadway deck were built the reinforcing steel for girders and cross-beams was placed. The connections between beams and girders were bulkheaded off, the girders poured and then the beams and slab concreted.

A combined statement from twenty-five of the larger electric railway companies in different parts of the United States, shows that for the year ending June 30th, 1915, there was a decrease of $3,601,948 in gross income, a decrease of $1,516,025 in operating expenses, and a decrease of $2,083,394 in net income as compared with the year ending June 30th, 1914.

WATER POWER FROM EXCESS WATER SUPPLY.

According to W. B. Conant, of Concord, Mass., writing in "Municipal Engineering," the Metropolitan Water and Sewerage Board of Boston, Mass., is about to undertake the utilization of the run-off at the dam of the Sudbury reservoir, a part of the metropolitan water supply system. The reservoir has a capacity of seven and a quarter million gallons. About 90 per cent. of the flow of water will be used to develop electricity, but without impairment of the required supply to Boston for ordinary uses. The Sudbury basin lies nearer Boston and below the greater Wachusett reservoir of the system, and receives the greater part of its water from the latter. A generating station was put in operation at the Wachusett dam in 1911 and has generated about five million kilowatt hours a year since beginning service. The electrical energy is sold to the Connecticut River Transmission Company at 0.53 cent per kilowatt hour, which represents a substantial return on investment to the Metropolitan Board.

The Edison Electric Illuminating Company of Boston has contracted for five years to take the energy produced at the new Sudbury generating station, at 0.625 cent a kilowatt hour. A 900-kva. and two 275-kva. vertical-shaft generators, directly driven by 1,000 and 300-h.p. turbines, will be installed in the present granite gate house on the crest of the dam. A head of 60 feet is available on the larger unit and of 35 feet on the two smaller wheels, which will be located in chambers beneath the generators. About 650 kilowatts will be the average output of the station, but sufficient water power is available to generate a maximum of 1,400 kilowatts.

It is noteworthy that the value of water for domestic purposes exceeds that for power generation by thirty or forty fold, but the fact remains that an investment of $125,000, in the case of the Wachusett station, yields a revenue of some $30,000 yearly, and it is expected the Sudbury undertaking will be proportionally profitable.

The contracts with the purchasers of the power provide that the primary uses of water in the two reservoirs shall not be interfered with in operating the generating plants. In other words, the surplus alone is used to produce electricity, and this is available at certain times and seasons. It is interesting to note that the demands of the cities for their domestic supply, and of the electric companies for the delivery of electricity, are reciprocal. The Connecticut River Transmission Company derives the greater part of its supply from its own hydro-electric station in the western part of Massachusetts, while the Boston Edison Company has relied hitherto entirely on steam generating plants.

The practicability of using the surplus, in the case of Boston's water supply, has already been fully demonstrated, and is creating interest among engineers in other cities.

DEVELOPMENTS NORTH OF EDMONTON.

The D. A. Thomas interests have begun construction and development work in the district north of Edmonton. Mr. C. F. Law, of Vancouver, representative of Mr. Thomas, is visiting The Chutes, near Fort Vermilion, where three test-holes for oil are being drilled. Three large steamboats are to be placed in commission north of Edmonton, so as to maintain an adequate transportation service on 2,400 miles of the northern waterways. It is expected that the first boat will be finished in time for the open water next year. In the Peace Pass, above Hudson's Hope, some of the company's men have located seams of high-grade bituminous coal.

STEEL PENSTOCKS AND DRAFT TUBES PROTECTED BY TAR PAINT.

After finding that a shop paint of red lead and oil was unsatisfactory and disappeared from the steel penstocks and draft tubes of the Minidoka power plant, the engineers set about to find a more permanent covering. Mr. Barry Dibble, engineer in charge of the plant, describes, in the Reclamation Record for September, their findings as follows:—

After considerable study and experiment, with unsatisfactory results, the following formula for red-lead paint, obtained from one of the largest paint manufacturers in the country, was adopted, the lampblack being used as a hardener for the surface:—

First coat: 30 lb. of red lead per gallon of linseed oil, using one-third boiled and two-thirds raw oil.

Second coat: Same as above, with 4 oz. of lampblack per gallon.

Third coat: Same as above, with 4 lb. of lampblack to the gallon.

Paint was applied according to this formula during the winter of 1912-13. After part of this work was done the chief electrical engineer suggested that we try the material used on the Los Angeles aqueduct, and in accordance with his instructions we ordered water-gas tar for the first coat and coal-gas tar for the second and third coats. This was applied to penstock and draft tube 1.

At the end of the 1913 season the red-lead paints applied according to the above formula showed decided deterioration where in contact with water, while the tar was in very good shape except for slight rust spots around some of the rivets, where cleaning evidently had not been properly done. At the end of the 1914 season the lead paint had almost entirely disappeared where exposed to water, and the tar paint was in good condition on the penstocks, but was apparently getting rather thin on the outside of the draft tube. Where the red lead does not come in contact with the water, as is the case on the upper part of the exterior of the draft tubes, it shows no deterioration and is now in excellent condition.

During the fall of 1914 the parts exposed to water on all the draft tubes were scraped, cleaned and repainted with water-gas and coal-gas tar. The accompanying table shows the cost of this work. There was a considerable variation in the condition on the different tubes, due to the fact that some had two coats of lead and some three, and also due to the fact that in some cases the weather was cold when the paint was applied, and it, therefore, may not have set sufficiently before being submerged in the water. The tar paint on draft tube 1 would under ordinary circumstances have gone a much longer time without renewing, but it was though' advisable to go over it in order to determine the condition of the tar coating and the iron underneath.

It will be noted from the accompanying schedule that a very large part of the cost of the work was involved in the cleaning. This cleaning was done by means of steel scrapers and brushes. With the lead paint the iron pitted badly, and it was necessary to clean out the loose scale thoroughly before attempting to repaint the metal.

The rivet heads, particularly, presented a serious difficulty with these scrapers, and we found it very slow to do a good job cleaning around them. After this work on the draft tubes was finished a special brush was made up which could be fitted over the rivet heads and revolved in a breast-drill frame. This worked very satisfactorily, and it materially reduced the cost of cleaning the penstocks.

In scraping draft tube 1 we found an excellent adherence between the metal and the tar paint, which had been on a year and a half at that time. Where it was scraped down to the metal it left a bright surface. On one patch, of about 1 sq. yd., apparently the iron had not been well cleaned before applying the paint, as it was in a place difficult to reach, and here scale had formed. This was the only place, however, where the iron had not been protected from the water. There was a marked difference in the ease with which this tar was cleaned off preparatory to repainting as compared with the work involved on surfaces which had been covered with red-lead paint, and had become pitted. It will be seen from the cost data that tube 1 was cleaned for about one-half the average for the other four tubes. Altogether the results with the tar have been most satisfactory.

Cost of Cleaning and Painting Five Draft Tubes, Minidoka Power House

	Draft Tube 1	2	3	4	5	Total
Total surface, sq. yd.	170	170	170	170	170	850
Area cleaned and painted, sq. yd.	150	150	150	150	150	750
Cost of scaffolding:						
Labor	....	....	....	....	....	$52.32
Material	....	....	....	....	....	22.74
Cost of cleaning:						
Sharpening scrapers	....	....	....	....	....	52.76
Labor	$37.42	$92.98	$58.00	$48.28	$85.10	321.78
Cost of painting, labor:						
First coat (water-gas tar)	7.40	11.99	2.60	6.70	12.93	41.62
Second coat (coal gas tar)	10.95	16.69	10.16	10.10	12.06	59.96
Third coat (coal-gas tar)	None	None	None	8.50	None	8.50
Total labor, painting only	18.35	28.68	12.76	25.30	24.99	110.08
Material (all coats)	2.40	2.11	1.60	2.40	1.88	10.39
Total cost	....	....	....	....	....	$570.07
Cost per square yard cleaned and painted						
Scaffolding, labor and material						$0.100
Cleaning, sharpening scrapers, and labor						0.499
Painting—						
Labor						0.147
Material						0.014
Total per square yard						$0.760

There was quite a variation in the consistency of the water-gas tar purchased at different times. As ordinarily obtained it was necessary, in the cool weather during which we painted, to mix a little gasoline with it. Usually the mixture was about 1 qt. of gasoline to from 3 to 5 gal. of tar. This tar was then spread on carefully with a brush in the same manner as ordinary oil paint, it being carefully worked into all pits and around rivets. One gallon of tar covered about 30 sq. yd. with one coat. The cost was about 15 cents per gallon, about one-half of which was freight charge from Chicago to Minidoka.

The tar is rather slow in setting, even if the weather is warm. It hardens when the thermometer drops, but when the weather warms up will become sticky, even after a considerable period. As most of the work was done in cool weather, it was possible to apply the second coat within 1 to 14 days. In only one case (draft tube 4) were we able to get a third coat on prior to the time when the weather turned so bad that it was impossible to do outside work. It does not appear to affect the tar to put it into the water before it is thoroughly hardened.

THE STATUS OF THE ENGINEER: HIS OBLIGATIONS AND HIS OPPORTUNITIES.

IN his address on Sept. 14th to the American Association of Engineers Professor F. H. Newell calls attention to the fact that the engineer is rapidly awakening to a realization of his duty to society in general, to his profession, and to himself in particular. He states that the quality which distinguishes the engineer as a professional man from his brother, the mechanic, is education. Also that the public must be educated to a better understanding of the service which the engineering profession can, and is, rendering, and the engineer must present his claims for recognition in such a way that they will be readily accessible to, and understood by, those not technically educated in engineering. For the lack of mutual relation and understanding the speaker shows the engineer to be, to a certain extent, to blame. This and other matters of similar importance are dealt with as indicated in the following abstract of Professor Newell's address:—

The present century is that of organization. The zeal for the study of efficiency, the demand for larger and more effective organizations, the value of preparedness, all of these are being forced on the attention of the thinking man; he is seeing as never before the need of organization and of sacrificing of some of his individuality in the interest of work for and with his neighbor.

What distinguishes an engineer? Before going further into details of this awakening, it may be wise to inquire what we mean when we speak of the engineer. It is a word in common use, but few of us can agree upon a definition.

The quality which distinguishes the engineer as a professional man from his brother, the mechanic, is education. The engineer is undoubtedly benefited if at the same time he is a good mechanic, although he may be a success even if he has little or no mechanical ability. To be an engineer in the true sense, he must have, however, that education which enables him to understand the true perspective of things, to know the big from the little, to obtain facts, and judge correctly from these.

Why should he serve? The education of the engineer, whether obtained through books or through things, has been largely at the expense of some other person—either society, the state, or his more immediate employers. It is safe to say that the great majority of engineers are indebted to some one for the opportunities which they enjoy; as a body they owe a duty to the state and to society as well as to their profession.

Ethics.—It is this recognition of duty which gives rise to the ethics of the engineering profession and which distinguishes the engineer as a professional man from the ordinary mechanic, who from lack of this education does not feel bound to the same degree by written or unwritten codes. These ethics are well recognized, although, like many other matters of common knowledge, they are often difficult of exact definition. We know when they have been violated, and yet may debate long as to the exact line between ethical and unethical conduct. The conception of engineering ethics is fundamental to the profession, and finds its highest expression in service.

Service to the public and to the engineering profession by means of service to the members, should be the motto of any organization of engineers.

What is this service which all should be eager to render and which is the fruition of years of training? What do we mean when we claim that the highest function of the engineer and his greatest reward is found in effective service? The word conveys the idea of help rendered to another, not as a favor involving an obligation, nor, on the other hand, as a matter of self-sacrifice. It is something which may be expected, though it cannot be demanded, and may be performed among equals. Service consists of those acts which tend to lessen trouble or increase the health, prosperity and convenience of others.

Engineers in performing service are by this very fact entitled to full recognition. Service implies a suitable reward, and, while the effort may be altruistic, it does not involve unnecessary self-denial. A proper remuneration, one assuring a good living, is due to the engineer. He who performs service rightfully does it with full expectation of reward, directly or indirectly, in the satisfaction of duty well done.

Among all the various occupations there is none which is more capable of leading in service to mankind and in realizing higher ideals than engineering. The engineer should be a man of vision—a missionary of light and progress. His life is devoted to careful, impartial measurement and weighing of facts. He cannot afford to be deceived or to mislead others on these facts; having ascertained them in their true proportion, it is then his business to idealize, to plan, and to use his ingenuity in devising methods for adding to the comfort and convenience of mankind, such, for example, as through better conditions of transportation, of communication, of heating, lighting, water supply, and of the things which tend to produce better health and longer life in the community.

Educating the Public.—In this work the engineer is far ahead of the public. The latter in many ways has not yet caught up with the growth of knowledge and does not appreciate the possibilities which are awaiting realization under the touch of the skilled engineer. The people as a whole do not as yet have the vision of better things which lie within their grasp and which can be called into being when ignorance is dispelled. Many a community is existing, or even declining, because it does not utilize the available water supply or have constructed the needed sewerage system. The more progressive people and the young men are leaving to go to localities where these better things are accomplished.

The public is not wholly to blame. The engineer in part is to a certain extent culpable. He has not fully felt the need of diffusion of information, except among his professional brothers. He has not taken the public into his confidence and explained in simple terms, in ways that would attract the public, the results already achieved, nor has he given these a setting or application such that the ordinary citizen and taxpayer can comprehend how this work affects him or how his condition may be improved.

Without attempting to discriminate very nicely between the different classes of men who may be considered as engineers, it is safe to assume that there are in North America over 100,000 men whom we would class as "engineers," outside of the purely mechanical occupations. Of these, over 40,000 are members of approximately 100 organizations. The greater part of this number is included in four great national societies. The hundred or more local engineering societies organized at the principal centres of population have a membership each of from 100 or less up to 500 or more, averaging about 200. The importance of these societies has not been fully appreciated, even by their members, and the most enthusiastic will hardly claim that they are as yet fulfilling their largest or best function. They have in one sense boundless opportunities for useful work if only they can grasp them.

The total membership of these local societies aggregates in round numbers 20,000, so that for the purpose of discussion we may say that of the 100,000 men who claim the right to be called engineers 20,000 are members of the four national societies with headquarters at New York; about an equal number, including many of the above, are members of local societies, leaving over 60,000 of the men not enrolled in any engineering organization.

In the latter group are many men of ability and standing in the profession who have never seen the necessity of joining with their fellows in organized efforts. By far the greater part, however, are the younger or less prosperous men who are performing routine work in engineering offices or engaged in the details of the country surveyor and engineer. As a whole, they include the more poorly paid professional men, whose compensation averages less probably than that of the high-grade mechanics. We do not have any definite data on this point, but those who have employed engineers and graduates of engineering schools are ware of the fact that, under present conditions at least, we can obtain the service of highly educated skilled engineers as computers, draftsmen, office or field assistants at a nominal wage.

It is not the "submerged tenth" but the six-tenths for whom special appeal should be made to ascertain whether their condition may not be improved by applying to it the same painstaking study to ascertain the true facts and to provide a remedy as should be done by the engineer to meet and overcome physical obstacles. If we can solve some of the great problems of control of electrical current, of storage of floods, of winning coal and iron from the earth, of devising ingenious mechanism, we should be able by using the same degree of intelligence to materially improve the human machinery. We have, however, in the past often overlooked the things which lie nearest to us while going to the unsettled west, or to the ends of the earth, to attempt tasks more remote.

To this large body of engineers there is being added each year about 5,000 recruits, mainly from the engineering colleges, more or less well trained in the fundamentals of engineering. There was a time within recent years when there was a demand for every one of these young men in active engineering work. At present, however, it is necessary that many of them go into other lines. It is not to be supposed that their education is by any means wasted, as the training of a good engineering college is probably the most valuable to be had in preparing young men for their life work in lines of trade and commerce. While during the first few years they may not receive salaries as high as that of other men of their age who have gone into business directly from the common schools, yet in the long run the training they have acquired gives them opportunities for more rapid and substantial progress.

One of the problems that is now confronting us is the fact that each year this large group of graduates, as well as the thousands of young men employed in engineering offices, are coming into a profession apparently overcrowded. This overcrowding, however, is more apparent than real. A relief is to be obtained not by limiting the influx of men, but rather by widening the field of service.

Opportunity.—The field is practically unlimited, the bounds extending with every improvement in the conditions favorable to human health, comfort and industry. Artificial limits, the cramping efforts of which we now appreciate, are set solely by ignorance. They exist only in the mind, and arise because of lack of knowledge by the public in general and of individuals in particular. To put it in another way, if every taxpayer and voter in the country, every town, city, county and state officer was fully aware of the conditions which surround him, and the extent to which the engineer could remedy or improve these conditions, there would be an immediate demand for all engineers who could be found. Take, for example, the matter of road-building. The public has been slowly educated toward the need of good roads, but not so fully to the fact that to build these good roads a certain amount of skill and experience is needed. We have the spectacle, surprising in a country which prides itself on its good sense, of millions of dollars being spent on new roads and in improving old roads, often without any preliminary survey or study of correct location or preparation of plans and estimates, nor of adequate supervision of the work, even if well planned.

The amount of money which is being wasted to-day in the amateur efforts of elected officers, who will be replaced next year by men no better qualified, would furnish employment to a great part of the engineers in the country. The point to be observed, however, is not that we are arguing for the employment of these men, but that the claim is based upon the far more substantial grounds of benefit to the public and to the man who pays the bill.

Take the matter also of public health. Imagine for a moment that every local official was aware of the conditions which are effecting the health of his community and of his family, and that he knew that these conditions could be remedied by intelligent and skilful engineers, and, moreover, that the cost of this work would be far less than the extravagant waste of time and money now taking place because of preventable sickness and death; would he not at once set about employing the men who could save not merely the money values, but what is far more precious, the happiness and lives of his own kind?

The opportunities are boundless—they stand on every hand ready for us when we awake.

Salesmanship.—To properly seize the opportunity the engineer who rises to the occasion must cultivate some of the qualities summed up in the term "salesmanship." We recognize that the success of many a merchant is due to a peculiar art which he has acquired and one which enables him to sell goods at a profit. We have more slowly come to recognize the fact that his success is due not to the fact that he personally makes a profit, but that the other party, the world to whom he sells, is benefited. It is true that for a time the merchant may sell inferior goods and may temporarily make money by so doing, but in the long run he has learned that the established business can only rest secure on honest advertising and on the realization by the public that he is performing a real service to mankind.

In the same way, the engineer to succeed must acquire the art of salesmanship. He may not recognize or label the quality, and may even deny its existence. He points to the code of ethics rigidly observed against advertising or self-exploitation, and yet, while conscientiously observing all proper rules of ethics, he may possess to a high degree the real art of presenting his ware in such a way as to convince the world that the general welfare is promoted by purchasing from him.

He has for sale not boots and shoes or legal opinions, but what is more difficult of delivery—he has ingenious but true ideals, he has imagination, trained by years of study and practice. He has acquired the power of making these "dreams come true," in proportion that the public or his employer recognizes these qualities, to that degree is he able to sell his wares. There is, perhaps, nothing more instructive to the young engineer than to try to ascertain the methods of salesmanship which have led to the recognition of certain well-known and respected engineers. Some have succeeded through or in spite of extreme modesty and a reticence which has been hard to break through; but in each case there has been not only true value of the goods to be delivered, but some quality of mind or action which has impressed upon others the fact that the goods are of superior value.

Parallel Line of Activity.—In the preceding paragraphs there have been very sketchily outlined the opportunities for service and an indication given of the great body of men who are available for such service to the community—one for which they are entitled to proper reward. In what has been said it is apparent that there are difficulties to be met. In the present awakening innumerable schemes have been suggested for action, but most of these fall under one or another of two principal lines:—

(1) Co-ordination and co-operation of existing engineering societies and organizations.

(2) Formation of one or more new associations devoted almost exclusively to the material welfare of the engineers.

These movements are the natural outgrowth of the discussion and unrest which has prevailed. They are not antagonistic, and may be mutually helpful. Not all men think alike, and the path which will be attractive to one group is not to another.

In establishing a new movement or society the burden of proof of the need of such organization is upon the promoters. If it is proposed to assume new costs and create new obligations, it must be clearly shown that there exists not only real need for this additional machinery, but that the public will be the gainer thereby. It is hardly to be expected under present conditions that any plans will be cordially received by the officials and by supporters of long-established and tested societies. As a rule, engineers are conservative. They prefer to trust to veterans in the cause rather than to new volunteers, and above all things look for the efficiency and economy which comes from unity of action.

We can, therefore, hardly present too strongly the arguments for branching out on any new line. In what has been said it may appear as though undue emphasis has been placed upon the public welfare and too little upon the benefit to the individual. It goes without saying that the individual must be convinced that he has much to gain in entering upon a new movement, but at the same time we must not lose sight of the fact that no such movement as is now discussed can be successful unless it is firmly founded on the public welfare. This may sound a strange doctrine to those who have not given thought to the matter; it is the popular conception that every business man is looking out for himself and that his success is based upon purely selfish considerations, and that every organization must do likewise.

Summary.—Summing up the needs and opportunities, it appears that a great part of the main body of engineers is not fully employed to the best advantage to society and to themselves, with corresponding loss to all. Nearly two-thirds of those who may properly call themselves engineers, or perhaps 60,000 men, are not members of any well-recognized organization, and are not utilizing their potential strength to help themselves or each other. There is need of enlightenment, of raising ideals and of united effort toward better things. The existing engineering organizations, which include perhaps 40,000 men, are devoted almost exclusively to technical questions as distinct from those things which concern the engineer as an individual and a citizen. Few of the older societies attempt to bring in the rank and file of the profession.

Assuming that the great mass of engineers are now awakening to a full appreciation of their opportunities, there is every reason to suppose that with the use of their united intelligence an early and sure progress can be made. We cannot at once overcome all of the inertia of the past, but with a wider diffusion of information we may confidently look forward to a rapidly widening field of work and a larger appreciation of results to be attained. If we could only comprehend the power for good that exists in the united effort of this great body of intelligent, experienced men we could see that nothing can withstand their efforts. Properly directed, they may bring about in the near future even greater progress than in the past in the promotion of general welfare by the development of new industries, the creation of new means of communication, as well as the improvement of those now existing to a point where the dreams of the most optimistic have become solid facts.

HYDRO-ELECTRIC DEVELOPMENT IN INDIA.

The advantages of electricity for power and light are now fully understood in India, although there is as yet practically no machinery manufactured in the peninsula. There are water power plants at Bombay, Mysore, Darjeeling, Simla, Kashmir and other points. The most important is undoubtedly the Tata Hydro-Electric Power Supply Company, Limited. This enterprise cost more than $2,000,000. It began supplying energy—some 60,000 h.p.—in February of the present year. Contracts have been signed for supplying to 31 cotton mills and three flour mills. This hydro-electric project was organized by an enterprising Indian capitalist and industrial promoter, and the financing was done largely by the native royal families.

In discussing a paper on "Tunnels" at the International Engineering Congress a few weeks ago, Mr. J. G. G. Sullivan, chief engineer of western lines for the C.P.R., outlined the use of the "pioneer bore" in driving the Roger's Pass Tunnel through the Selkirks. He pointed out that owing to its use it has been possible to keep men at work drilling, mucking and loading except where shooting is actually in progress. As a result the contractors have broken the American record in tunnel driving. Whereas the original offers of contractors for driving the tunnel called for completion in seven years, the bore will actually be finished in three and one-half years, half of this being taken in the approaches. He emphasized that the scheme was applicable only in hard rock.

MACHINERY AND POWER PLANT ON CONCRETE FOUNDATIONS.

By Norman G. Meade.

FOUNDATIONS for machinery have two functions—to keep the latter level, with all parts in alignment, and to absorb shock and vibration. The prevention of vibration is mainly dependent on the weight of the foundation. Individual motors, motor-driven machines, such as pumps, fans, etc., motor-generator sets and booster outfits require various kinds of foundations, the selection being governed by the weight and speed of the machines. The construction of the building in which the machinery is installed also has much to do with the method of support. For a given horse-power the support or foundation for a motor depends a great deal on the speed, and if belted, on the pull on the belt and the belt angle. Motors mounted on columns or walls are liable to cause trouble from vibration, and where possible it is best to mount them on the floor.

Where vibration is not objectionable, small machines may be mounted on a timber frame bolted to the floor. It is ordinary building practice for stores, factories and warehouses, to design the floors to sustain a weight, in addition to the weight of the floor, of about 150 lb. per sq. ft. Where the floors are constructed of wood and vibration is objectionable, small motors, say, up to 10 h.p., may be mounted on a spring base, consisting of two timber frames approximately the size of the motor base, separated by helical springs at the four corners. The lower frame is bolted to the floor and the motor base is fastened to the upper frame by coach screws. The safe carrying capacity of a helical spring may be determined from the following formula:

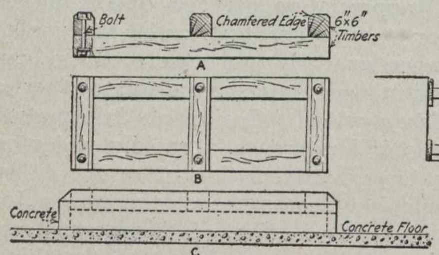


FIG. 1

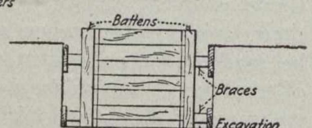


FIG. 2

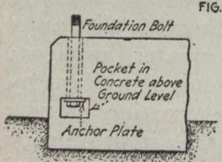
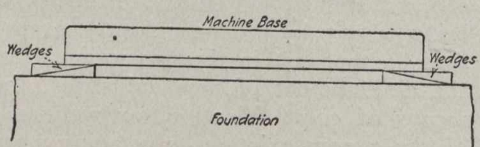


FIG. 3



$$W = 11{,}781 \frac{d^2}{R}; \text{ where}$$

W = safe carrying capacity in pounds;
d = diameter of rod material for spring in inches;
R = mean radius of coil (*D-d*, where D is the outside diameter of the coil).

Assume a spring where $d = 0.5$ in. and $R = 2$ in.; then

$$W = 11{,}781 \frac{0.5^3}{2} = 736 \text{ lb.}$$

Four springs of like dimensions will support a weight of $736 \times 4 = 2{,}944$ lb.

Obviously the other factor of the formula can be found by transposition.

For mounting machinery on concrete floors a good foundation is made as shown in Fig. 1. A wooden framework of 6x6-in. timbers bolted together is secured to the floor by bolts and is filled and surrounded with concrete. The height of the concrete should equal that of the framework.

On first floors of buildings where the distance to the earth is small, regulation concrete foundations are advisable. Concrete is comparatively inexpensive, is lasting and will support from 4 to 15 tons per square foot. The stones used in the concrete should not exceed 2 in. in any direction, and the particles should not be too uniform, as the smaller pieces fill up between the larger ones and the sand and cement fill the voids.

Excavations should extend below the frost line and should be filled in for about 6 in. with well-tamped sand if the location is dry, but if surface water is likely to percolate into the excavation a layer of gravel about a foot thick should form a base for the concrete. A form for a concrete foundation is shown in Fig. 2. It consists of wooden planking attached to battens which are braced against the sides of the excavation.

Good proportions for concrete using Portland cement are: Cement, 1 part; coarse sand, 2 parts; broken stone, 5 parts. The ingredients should be thoroughly mixed dry, and after mixing add just as little water as will completely wet the material. Concrete should be placed carefully. It should be thoroughly rammed in from 6 to 9-in. layers, and after setting, the top of each layer should be cleaned, wet and roughened before placing another layer. The weight of good concrete per cubic foot dry is from 130 to 160 lbs. If the earth is firm and dry in the excavation, the wood forms may be omitted, as filling out the inequalities makes the foundation much firmer.

There are numerous ways of placing foundation bolts, but it is always well to have an open space around them so that they may be sprung somewhat to enter the holes in the machine base. A good way to accomplish this is to place the bolt in an iron pipe about twice as large in inside diameter as the outside diameter of the bolt.

Foundation bolts should be in concrete foundations to a depth of at least fifty diameters. The diameter of the bolt should be the diameter of the hole in the bedplate less about one-sixteenth of an inch. Where foundations are deep enough, it is well to locate the anchor plate and nut in a pocket in the concrete above the ground level, as shown in Fig. 3. This permits removal of the bolt if necessary.

After the foundation is completed and set, the machine should be placed in position over the foundation bolts and carefully levelled by means of two wedges placed together on at least each of the four corners as shown in Fig. 4. Levelling is accomplished by hitting the upper wedges with a sledge. When level, the space between the under side of the base-plate and the foundation should be well grouted.—"Power."

RUSSIAN TRADE REQUIREMENTS.

A Canadian, who for many years has been in charge of important machinery interests in Russia, says that the principle of firms combining in groups or syndicates in order to work the Russian market is a good one, but those who want to make a success, must go over and investigate for themselves. Doing business direct from Canada is of little avail. In any case catalogues in Russian, and in the weights and measures and currency of the country are indispensable.

WATER POWERS OF THE MARITIME PROVINCES.

THE most complete and up-to-date review of the water powers of New Brunswick, Nova Scotia and Prince Edward Island is that prepared by K. H. Smith, B.A., engineer of the Nova Scotia Water Powers Commission, for use at the International Engineering Congress at San Francisco. It is one of the five pamphlets relating to Canadian water powers, distributed in connection with the Dominion Water Power exhibit. From it the following notes are reproduced:—

The Maritime Provinces have a total area of 51,512 sq. mi. and a population of about 975,000. Although drainage areas are comparatively small, this handicap to power production is largely overcome by heavy rainfall and numerous excellent storage facilities, particularly in Nova Scotia. The annual rainfall in New Brunswick ranges from 35 to 47 inches, while in Halifax the average precipitation for 35 years is over 57 inches.

There are several large power sites, comparable in size to other water powers throughout Canada, notably at Grand Falls, on the St. John River, as also on the Mersey, Gaspereaux and East Rivers, in Nova Scotia. An added feature in connection with these sites is that they are at or near navigable water. Grand Falls is at the head of navigation on the St. John River, while the other sites mentioned are close to excellent ocean harbors, such as at Liverpool, Sheet Harbor and Minas Basin.

The Maritime Provinces are particularly rich in timber and minerals, such as iron, gold and coal, and it would seem that some of the larger sites could be very profitably developed in connection with large industries founded on these natural products. It is probable that in the near future electrical energy will play a large part in the reduction of various iron ores and the manufacture of certain kinds of steel.

A number of smaller sites in Nova Scotia are so situated as to be of great service in connection with gold mining. Already some development along this line has been done at Isaac Harbor, but examples of much greater magnitude are to be found in the Yukon Territory, Canada, where two plants, one of 10,000 h.p. capacity, are utilized for this purpose.

Existing developments are mainly of two types: first, those based on the timber resources of the country, such as saw mills, pulp and paper mills; second, those developed and used by small municipalities for local lighting and small motor loads. In a few cases, too, small water powers are used to drive woollen mills and grist mills. The largest water power plants are used for the manufacturing of pulp and paper. In this field particularly, many excellent opportunities for the use of water power are available. The interior of New Brunswick is one vast forest, with timber especially adapted for pulp and paper-making purposes. Large areas could, no doubt, be made to produce pulp-wood perpetually by the application of approved forestry methods. The development of small powers for local municipalities is also a promising field, while in some cases larger powers near the sea coast offer exceptional opportunities for industrial activity.

On the whole, it appears that the available water power in the Maritime Provinces is ample for all present and future needs. Present developments for pulp and paper purposes and for local domestic or municipal use point the way to future expansion along those lines, while in the foregoing three, as yet only slightly exploited fields, more or less peculiar to the country are suggested: first, in connection with the application of electrical energy to agricultural pursuits; second, in connection with mining industries; third, in connection with industrial activity at seaports.

Water Powers Already Developed.—It is estimated that in New Brunswick there has been developed to date about 13,000 h.p. Of this amount 56 per cent. is used by small saw mills, grist mills and pulp mills, while the balance is made up of small electric plants from 100 to 500 h.p. capacity, and one plant with 3,800 h.p. installed. This plant, one of the largest single electrical developments in the province, is located at Aroostook Falls, but the greater part of the output is used in the State of Maine. Small plants exist at Bathurst, Centreveille, Edmunston, St. Stephen, Shediac and Woodstock, all of which are privately owned, except the Edmunston development, which is a municipal enterprise.

In Nova Scotia about 21,000 h.p. has been developed. Of this amount, 12,650 h.p. is used in the manufacture of pulp and paper, 2,700 h.p. consists of small electric light developments, 350 h.p. is used for gold mining purposes at Isaac Harbor, and the balance is made up of numerous saw mills and grist mills. Small electric light plants exist at the following places: Annapolis Royal, Bear River, Bridgetown, Bridgewater, Dartmouth, Liverpool, Lunenburg, Yarmouth and Shelburne. The plants at Annapolis, Bridgewater and Liverpool are owned and operated by the municipalities, and one of the largest single electrical developments is that supplying the town of Liverpool. This plant is on the Mersey River and has 750 h.p. installed. Two comparatively large pulp and paper mills are also situated on the Mersey River, the upper one having a capacity of 3,000 h.p., and the lower one 1,500 h.p. On the Sissibou River, at Weymouth, there is a pulp mill with 2,000 h.p. installed, while other similar developments exist on the Lahave, Medway, Clyde and St. Croix Rivers.

So far as Prince Edward Island goes, nearly every stream has one or more small water power developments, ranging from 5 to 50 h.p. Such developments are used in connection with small mills of various kinds, principally grist mills and woollen mills, and rarely operate throughout the whole year. There is one hydro-electric development on the Montague River, supplying the village of the same name, where 44 h.p. is installed. It is estimated that 500 h.p. is developed on the Island.

Undeveloped Water Powers.—One of the chief assets of the Maritime Provinces in undeveloped water powers lies in the large number of small sites available for domestic use or for small municipalities. One or more such sites exist on practically every stream throughout the district, and a number of municipalities, as outlined above, have already taken advantage of some of these opportunities. There are, however, a number of places where large amounts of power may be developed, some of which have been given considerable attention, and it is only a few of these larger sites that can be mentioned here. There are two outstanding power sites in New Brunswick, Grand Falls on the St. John River, and Grand Falls on the Nepisguit River. The St. John River drains by far the largest basin of any river in the Maritime Provinces. The total area of this basin is 26,000 square miles, of which about 5,000 square miles is within the State of Maine. The largest water power in the Eastern part of Canada exists at Grand Falls, on this river, about 200 miles from the city of St. John. A scheme of development has already been outlined whereby it is proposed to install 80,000 h.p. under a head of 140 feet. There is another place on the river, known as the Pokiok site, much nearer St. John, where there is said to be about 30,000 h.p. available.

The Nepisguit is a very rugged stream in the northern part of New Brunswick, with headwaters adjoining those of the Tobique, a tributary of the St. John. There are a number of rapids and falls on the Nepisguit, the most spectacular of which is Grand Falls. This is located about 20 miles from the town of Bathurst, and upwards of 10,000 h.p. is available with a head of 125 feet. Such rivers as the Miramichi, Tobique and Aroostook are also known to have a number of large power sites.

In Nova Scotia, three possible sources of comparatively large amounts of power have been considered, and construction on a fourth has been started. The Mersey River, commercially the most important river in the province, has exceptional storage facilities in lakes at its headwaters. There is said to exist on it the possibility of developing upwards of 30,000 h.p. at several sites. As yet only 4,250 h.p. has been developed at three different places. East River, Sheet Harbor, is also said to be capable of producing 16,000 h.p., and has excellent storage facilities on numerous lakes scattered throughout the drainage basin. The Gaspereaux River is also well supplied with storage basins, and, according to a scheme outlined by a reputable firm of engineers, it is possible to obtain 8,000 h.p. from this river under a head of 450 feet. Such a development in the heart of the best farming district in the province ought to be very valuable, and besides, is within transmission distance of the city of Halifax. Work has been started on an unique scheme within twenty miles of Halifax, the output of which is intended to supply that city. This scheme, besides storage in a number of lakes, involves the entire diversion of one stream into another and the installation of turbines acting under different heads in the same power-house. The combined flow of the two rivers is again to be used in a second power-house, situated at tide water, on St. Margaret's Bay. It is estimated that 2,160 continuous horse-power may be obtained from this plant as well as 3,210 h.p. extra for 12 hours daily.

VARIED USES OF WOOD PULP.

The report that the Germans are using wood pulp in place of cotton for the making of propulsive explosives is drawing attention to the miscellaneous uses to which this material is now being put. As is well known many articles of clothing are now made from wood pulp. The consumption of this substance in meeting the world's demand for newsprint and other paper attains to an enormous figure. Wood pulp also enters into the manufacture of cigarette and cigar holders, fancy combs, buttons, handles for umbrellas and sticks, insulating materials for electrical fittings and films, and various other articles. In the form of a solution it is largely used in the treatment of fabrics, for accoutrements, and in other directions. Wood pulp is now used as a raw material in industries, which employ thousands of people and the present demand upon factories making articles from wood pulp is very strong.

There are at the present time something over 7,700 miles of the Canadian Northern lines in operation in various parts of Canada, with another 1,250 miles ready to be thrown open for traffic. With the opening of this additional section a continuous line of railway will be operated by the company between Port Mann and Quebec.

SOME BITUMINOUS PAVEMENT COSTS.

In a paper read last May before the Oregon Society of Engineers, Mr. R. G. McMullen, of the Department of Public Works, Portland, Ore., states that the engineers of that department have found the cost of mixing one square yard of bituminous pavement two inches thick to be 6 cents per square yard. The cost of hauling is on the ton-mile basis, using auto trucks of five tons capacity. The cost of operating one five-ton truck, as compiled from records for 1914, is as follows:

Salary of driver per day	$3.50
Wear on tires per mile	.05
Depreciation on truck per mile	.04
Repairs to truck per day	2.00

Gasoline consumed at the rate of four miles to one gallon, lubricating oil at 80 miles to one gallon, grease at 10c. to 15c. per day, interest on the original cost of truck, 6 per cent.

They figure the repairs to truck at $2 per day for every day in the year, making $732 per year. From the above unit prices the cost per ton-mile has been calculated and shown to be as follows: One mile, .161c.; two miles, .250c.; three miles, .355c.; four miles, .465c.; five miles, .562c.; six miles, .630c.; seven miles, .680c.; eight miles, .728c.; nine miles, .768c.; ten miles, .800c.

The tabulation is for 1 cubic yard which weighs from 2,800 to 3,100 lbs. Reducing the cost of haul from the cubic yard basis to the ton-mile basis, the cost averages for a 7½-mile haul $0.572 per square yard. One ton of mixed material lays 9 square yards of pavement, 2 inches thick, after compression. Therefore, for convenient reference, a rate of 1 cent per mile for 1 square yard of pavement is enough to cover cost of haul.

The cost of hauling crushed rock for a base 1½ inches thick, used for spreading over old macadam, would be for a 7½-mile haul, $.038 per square yard. The cost of scarifying old macadam would be $.06 per square yard. The cost of spreading and rolling new base, 1½ inches thick, would be $.028 per square yard. The cost of spreading and rolling the top or wearing surface, 2 inches thick, would be $.06 per square yard.

In addition, 20 per cent. has been added to cover overhead charges, accounting and incidentals, which makes the total cost of laying pavement $0.599 per square yard.

There will be considerable fluctuation in the percentage added, as the details of some parts of the work will cost more, and some less, than 20 per cent.

In addition to all the costs referred to, an additional cost has been added, that of 10c. per cubic yard for the handling of the raw material at the mixing plant, as some of the material has to be moved 50 or 60 feet from stock piles to the mixer.

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended October 1st, 1915:—

McKinley-Darragh-Savage Mines, 83,000; Dominion Reduction Company, 88,000; Buffalo Mines, 61,080; La Rose Mines, 87,129; O'Brien Mines, 84,359; Coniagas Mines, 64,191; Mining Corporation of Canada (Townsite City Mine), 59,203; Mining Corporation of Canada (Cobalt Lake Mine), 172,665; Peterson Lake Silver Mine, 147,649; Timiskaming Mining Company, 85,831. Total, 933,107 pounds, or 466.5 tons.

The total shipments since January 1st, 1915, are now 23,522,431 pounds, or 11,761.1 tons.

ENGINEERS AND WAR.

By R. O. Wynne-Roberts, Consulting Engineer, Toronto.

(Concluded from last week.)

Communication.—Transport has always been a great problem in war. Reference has already been made to the construction of roads and bridges in the early ages. In Asiatic Turkey many districts have remains of bridges built by Romans and Greeks, for since then scarcely any others have been built. Napoleon found it difficult to maintain an adequate supply of munitions during the progress of battles, and the movements of his troops were thereby hampered. He therefore built many roads and bridges which are in use to-day. The army that can transfer its troops and its equipment the most expeditiously has the greatest hope of winning. This was clearly noticed in the recent German progress in Poland. The Germans have a magnificent system of railways and roads leading to and skirting the border, whereas Russia has few of these facilities. The normal movement of troops under favorable conditions in time of peace is slow. For instance, the United States army authorities recently had a number of troops with ordinary equipment march from Texas City to Houston and back. Even with all reasonable facilities, the average rate of travelling was only 12 miles per day. As the army depends absolutely upon food and supplies, means of rapid communication and transport are essential. The movement of artillery, especially the heavy pieces, unless transported by means of motors, over passable roads, calls for an enormous supply of horses. A few years ago it would be necessary to employ 38 to 48 horses to remove a 42 centimeter gun. These had to be relieved every four hours to keep continually moving. In all, 114 or more horses were required for each gun of this size.

The maintenance of roads at the front must constitute an enormous task. The writer, during the South African war, had the supervision of roads in Capetown, and one of them connected the harbor with the transport headquarters. This particular road was traversed many times a day by ponderous military traction engines and trailers loaded to their full limit, which seriously cut up the road. It was repaired one Sunday with best available macadam, yet by the following Sunday the road was in as shocking a condition as ever; all the macadam had been pulverized to dust. This is no doubt what is occurring at the front at the present time. Those who have not experienced the results of military occupations may glean some idea of the enormous work involved. The Scientific American calculates that if 1,200,000 Germans marched unopposed along one road, the men, wagons, guns, ambulances, hospital equipment, ordnance, supplies, etc., etc., would stretch from Paris to within 400 miles of Moscow, or applying the illustration to Canada, it would extend from Ottawa to Winnipeg, a distance of 1,200 miles. One reason for the Germans passing through Belgium and Northern France was doubtless the fact that good level roads were there available. The repeated passage and travelling back and forth along these roads, together with the devastating effect of high explosives, must have damaged these roads beyond our comprehension.

Mr. Massey, writing to the Daily Telegraph (and quoted by the "Surveyor") refers to the work of the Italian engineers in the present war. The Italian troops are fighting in the mountainous regions of Trentino. Roads have been blasted out of the solid rock, thrown across ravines, built up the craggy heights of the Alps, skirting precipices, zig-zagging in concealment, and existing roads which were blown up by the Austrians have had to be repaired. "While Bersaglievi and Alpini held the approaches, the engineers went forward to make the positions secure."

In the American Civil War the engineers built no less than 580 miles of corduroy roads, and surveyed 6,780 miles of dirt roads.

The building of military bridges is another engineering problem. In 1864, during the Civil War, General Sherman required a pontoon train of 12 boats to be sent a distance of 306 miles, which occupied 10 days. During the campaign 3⅓ miles of pontoon bridges and 1¾ miles of trestle bridges were thrown over rivers. The longest pontoon bridge was to cross the James River at Fort Ponhaton, the length being about 2,000 feet. This work was carried out by Colonel Benham under difficulties.

The widest stream crossed by Germans in this manner is said to be about 325 feet; widths exceeding this are crossed by ferries. The reason for this is probably accounted for by the weight of the pontoon and bridge materials. Each pontoon weighs about 3,600 pounds, and with the wagons, etc., require four horses to haul. As many pontoons are required to cross an ordinary river, it will be seen that when many crossings are made the work involved is very great.

Much is heard to-day of the destruction of railways in Russia to cripple the progress of the invaders. During the American Civil War the engineer at Atlanta on one occasion destroyed 12½ miles of railroad by burning every tie and bending every rail.

Engineers have introduced so many changes in the methods of communication that it is no hyperbole to state that they have reduced the dimensions of the world, as measured by time, to the merest fraction of what it was 100 years ago. The news of the battle of Trafalgar and Nelson's victory was not heard of in Naples for over seven weeks. The report of the battle of Waterloo and Wellington's defeat of Napoleon was received in London by messenger. The telegraphs in South African native and other wars over 50 years ago consisted of semaphores somewhat like our present railway signals and when the authorities were invited to use the electric telegraph the idea was turned aside as impracticable.

Newspapers were possible by virtue of the ingenious machinery designed to turn them out in thousands per hour. Yet, in time of war, newspapers can help the enemy. The disaster to MacMahon during the Franco-Prussian war of 1870, when he attempted to relieve Bazaine, who was besieged at Metz, was due to the fact that the Prussians got information of the movements of the French from the French and English papers. Every known means of communication are now used by the European belligerents and perhaps this fact may have contributed not a little to the stalling of the immense armies within sight of each other.

Transport.—The development of the internal combustion engine made it possible to utilize mechanical power in place of animal energy. Steam power was used for road transport in 1801, and there are plenty of examples of steam-driven vehicles to-day, but for general use internal combustion engines appear preferable. That mechanical transport has proved so great a success is largely due to the close attention which has been given to the purely technical side of this branch of service. Food, ammunition, men, etc., are transported by thousands of motor vehicles. The Germans were able to make their rapid descent on Paris by the aid of motors for cannons, ambulances, searchlights, food supplies, repairs, etc., etc. An immense number of quickfiring guns are mounted on automobile trucks, converting them into travelling forts. Some idea of the great demand for motor vehicles may be gleaned from the fact that $13,000,000 worth were ordered by Russia alone, whilst the Allies in nine months received motor vehicles to the tune of $57,000,000 from the United States.

Water Supply.—It will be acknowledged by all that the question of water supply is of paramount importance to the troops. In the South African war more men fell from enteric than from wounds. This has been the record of most wars. The engineers' expedition to Abyssinia in 1864 was fitted with filters but the writer has no data at hand showing the results obtained. The quantity of water actually required does not amount to much when reckoned individually, but for the huge European armies the total will be very great and this, of course, increases the task of furnishing pure water. The United States troops who marched from Texas City to Houston consumed only two gallons of water per head per day for cooking and drinking, and the horses drank 6½ gallons per animal per day.

The progress in the art of water purification during the last fifty years has been considerable, although not so great as might be expected. Sedimentation and filtration were practised long ago, but the technique has been developed during the last generation. We know better to-day how to treat water scientifically and can ascertain the results more accurately and reliably. Bacteriology has furnished the key by which our knowledge of water purification has been expanded. Now water for the soldiers can be sedimented, filtered, and sterilized in a manner which was never before possible. The study by engineers and bacteriologists of the use of rapid filters and various types of sterilizers has made it possible to make water which is seriously polluted, reasonably safe for dietetic purposes.

Sewage treatment and disposal and refuse disposal in camps or on battlefields are now carefully organized. Reports from France clearly show that every precaution is taken by the Allies against insanitation. Mr. G. B. Hartfree, the engineer to the Alton Town Council, England, has written a series of most instructive articles in the "Surveyor" on "The Surveyor in Military Service." (The term surveyor in this connection is synonymous to town engineer.) The articles are now available in book form at a price of about 25 cents. They deal with the selection of camping grounds, billeting, sanitation, cooking arrangements, heating, refuse disposal, water supply, bridges, hospitals, hot water, miniature rifle range, etc. Whilst the supervision of the sanitary work of the army is attended to by the medical branch, much of the executive work must perforce be carried out by engineers, as—the lighting, heating and ventilating of hospitals, the drainage, water supply, sewage and refuse disposal of permanent camps and barracks, and so on. In active service the problem is somewhat difficult, for then the supply of requisite equipment is not always available but the work must nevertheless go on. So the engineer is there called upon to utilize the things that are at hand, build with uncompromising materials and adapt everything to the service of the moment.

Woodshops.—No army can subsist long without supplies from the base. The present war shows that to maintain a soldier at the front probably two civilians must remain at home to keep him supplied. The list of articles required to carry on war is enormous, and when it is examined its magnitude increases rapidly, for directly or indirectly the list involves almost every line of industry and labor. To supply even leather boots, the farmer, butcher, fellmonger, tanner, and shoemaker must each do his bit, whilst the machinist must build contrivances to expedite the mechanical processes. Take high explosives: much of the toluol, picric acid, trinitrotoluene are by-products of gas manufacture, hence the anxiety of the Prussians in particular to maintain an ample coal supply for their gas works in Germany and Prussia to produce these and other valuable things. The miner, gas stoker, etc., distiller, chemist, and the mechanic must carry out their duties to obtain these raw materials. Cotton must be obtained and treated with nitric acid to form nitro-cellulose or gun cotton. Glycerine can be made from lard or other animal fats. Whatever munition of war is considered, it means the employment of many hands and the concentration of many minds and the devotion of years of erudite research to produce it and to make it superior to the enemy's products. The workshops of Europe and America are working at high pressure to enable the great armies to fight. Ordinary business has been virtually suspended so that munitions of war may be supplied. Shipping has been diverted from ordinary commercial operations to transport men and munitions. Engineers of all ranks and classes are striving to make the Allies supreme, and consider the subject from any angle, it will be found that the engineer is one of the most necessary of men, both behind the firing line and also at the front.

Two points further and this article will close. First, one lesson of this war is that the design and construction of machines should be modified so as to ensure more rapid production with existing machine tools. In a sudden call for munitions and the consequent enormous demand for special machinery so that the specifications are conformed to, much valuable time is lost before such special machinery is made and installed; whereas, if the designs and specifications were modified it would no doubt be possible to start work immediately and turn out the parts more rapidly and more cheaply. These are the summarized views of men competent to judge. The other point is that whilst engineers are willing to serve the nation to the full capacity, the Admiralty Board of Invention and Research has only one member who is actively engaged as an engineer, namely, Sir Charles Parsons. Whilst it is desirable to have the most highly accomplished scientists, it is also desirable to have men who know and know how from the practical point of view.

ONTARIO'S MINERAL OUTPUT

The output of the metalliferous mines and works of Ontario for the six months ending June 30th, 1915, as reported to the Ontario bureau of mines, is shown by the following table, which gives also the production for the corresponding period of last year:—

	Six months, 1915.	Six months, 1914.
Gold	$3,570,072	$2,011,069
Silver	5,188,763	7,053,418
Copper	1,229,894	1,197,059
Nickel	3,393,528	2,872,843
Iron ore	288,296	118,119
Pig iron	2,856,040	4,429,664
Cobalt	34,443	22,581
Cobalt oxide (including nickel oxide)	56,812	379,152

A LIGHT AND USEFUL ROOF TRUSS.

THE erection of the framed superstructure over the aëration tanks at the new sewage disposal plant in Edmonton, afforded the opportunity to use for the first time in connection with such works in Canada, a very handsome and yet simple and economical roof principal. The particular design is known as the "Belfast Truss," on account of its having been originally introduced by Messrs. Francis Ritchie and Sons, Limited, of Belfast, and used by them in roofing many industrial concerns in the north of Ireland and the Midlands of England.

The principal claims which this particular class of roof has for the attention of Engineers are: (1) Economy in material and carpentering work, and consequent low prime cost; (2) small superficial area of the roof in relation to the area covered by it; (3) the possibility of practically eliminating wind pressure as a factor in the stress calculations; (4) durability; (5) simplicity, lightness and pleasing appearance.

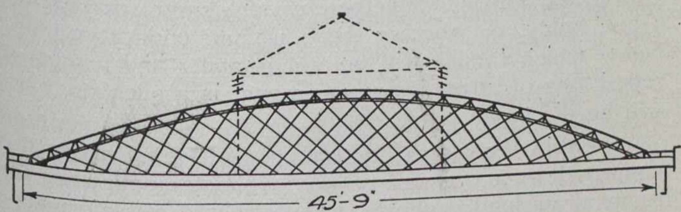


Fig. 1.—Wooden Truss in Outline.

The clear span across the aëration tanks above referred to is 45 feet 9 inches, but the truss can with equal facility be used on spans up to 120 feet—a consideration of the greatest importance where the roofing of the various units of sewage disposal or water filtration plants has to be faced, on account of climatic conditions, or from sanitary or other reasons.

Fig. 1 shows the truss in outline, the dotted lines indicating the ease with which a skylight and louvre ventilation can be obtained. The truss may be used on spans up to 120 feet. Fig. 2 shows a cross-section of the truss at the centre of the span, and an elevation of part of the string, bow and lattices to the same scale. In the case of this 45-ft. 9-in. truss the following specifications apply: Purlins, two parallel scantlings each 4 in. by 1 in.; bow, two parallel pieces of pitch pine each 3 in. by 1¼ in.; lattices, 3-in. by 1-in. spruce; string, two parallel scantlings, each 10 in. by 1½ in.; sole piece, 5-in. by ¾-in. spruce.

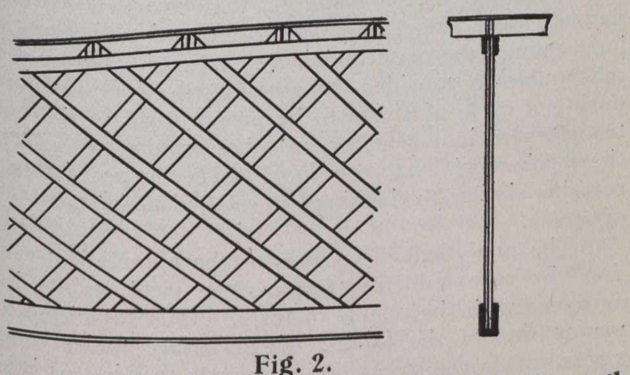


Fig. 2.

String, Bow and Lattices (Enlarged Elevation). **Cross-Section Through Truss at Centre of Span.**

The roof principals, in the particular case under consideration, are placed 10 feet apart c. to c., and the dead load to be carried by each was estimated at 12,000 lbs., made up of the weight of the truss itself, with the superimposed load of purlins, shiplap, "Ruberoid" roofing, and a possible snow load.

The bending moment is zero at the point of support, and maximum at the centre of the span, and between these points it varies directly with the distance from the point of support. If the bending moment is calculated at any number of points between the support and the centre, and ordinates erected to a uniform scale, the line joining the extremities of the ordinates will be found to form a parabola, and the bow of the truss in question is such a parabola.

In a truss such as the one under consideration there are no secondary stresses in the fibres of either string or bow, and so stress and strain are uniformly distributed over the cross-sections of these members. For this reason the allowable unit stress may be much greater than would be the case in a solid beam of wood. Furthermore, the extraneous roof load is applied to the truss through the purlins at a great number of evenly distributed points, and is partly taken care of by an immense area of lattice members, which might almost be considered as a solid web.

No apology is necessary for introducing this particular truss to the attention of engineers, because its adaptability to just such purposes as those described above give it a claim to recognition.

THE SURVEY OF CANADIAN QUARTZ MINERAL CLAIMS.

THE Canadian Government employs a number of surveyors in laying out quartz mineral claims. Most of this work is carried on in the Yukon, though a considerable number of coal, iron and the baser metals surveys are being carried on in Alberta, Saskatchewan and Manitoba. These surveyors work under the direction of the Surveyor-General at Ottawa.

Before beginning the survey of a mineral claim the surveyor is expected to make a thorough examination of the evidence in the mining recorder's office relating to the mineral claim to be surveyed, and to the adjoining over-lapping claims. He also procures all further evidence available on the ground.

Every mineral claim is designated by a lot number in the group to which such lots belong. The numbers of the lot and group must be obtained from the Surveyor-General at Ottawa, or, in the Yukon Territory, from the commissioner. All the boundaries of a claim must be run out, measured and marked in the ground, unless impossible from the nature of the ground, in which case a closed traverse may be substituted.

Boundaries in the woods are well opened up and blazed. The line is begun by retracing the location from post No. 1 to post No. 2, and measuring its length and bearing. The surveyor particularly ascertains and measures carefully the position of the discovery post. Should location post No. 2 of a mineral claim be more than 1,500 feet from location post No. 1, or more than 40 chains in the case of a location for iron or mica, the surveyor plants another post in the location line at a distance of 1,500 feet, or 40 chains, as the case may be, from post No. 1, but not disturbing the original location post No. 2.

Overlapping.—In surveying a claim which overlaps, or is in dispute with another mineral claim, the surveyor notes all the intersections of the boundaries of the two claims, and if the other claim is unsurveyed, its boundaries are surveyed to an extent sufficient for determining the intersection. The surveyor has no authority to decide whether a claim is valid or not; his duty is to note all adverse overlapping claims as he finds them and show them on his plan and in his field notes.

Monuments.—The monument used consists of a legal post with a mound and pits. The post must be at least four feet above ground faced on four sides at least one foot from the top. Posts in all cases are placed in the centre of the mounds.

The original location posts of a quartz mining claim are to be left by the surveyor alongside of those planted by himself. Posts Nos. 1 and 2 of a mineral claim are those at the extremities of the location line; the other posts are numbered from 3 upwards, consecutively around the claim. The post in the monument of any corner or angle is marked upon one face with the number of the lot preceded by the letter "L," and upon the opposite face with the number of the post. When an angle is inaccessible for the erection of a monument, a witness monument is erected at the nearest suitable point, bearing the marks of the corner post it is intended to represent, and in addition on a third face, the letters "WIT" followed by the distance in feet or in links, as the case may be, to the true corner or angle.

THE FAILURE OF MATERIALS UNDER REPEATED STRESS.*

By H. F. Moore and F. B. Seely.

THE behavior of materials under repeated stress shows important variations from the action under static stress. Nearly all the ideas of repeated stress have been developed from considerations of static loading. One very common idea is that for any given material there is a definite elastic limit below which the behavior of the material is perfectly elastic. Under static loads such a conception may be regarded as exact without involving serious error, though careful writers on the mechanics of materials have for a long time recognized that no absolute elastic limit has ever been fixed for any material. In structures under static load local stresses of considerable magnitude—frequently beyond the yield point of the material—exist without producing any appreciable effect on the stability or the deformation of the structure as a whole, and such stresses are frequently neglected in structures subjected to static load. If, however, the load on a structural part or a machine member is repeated many times such local overstress may cause a crack to start which, spreading, eventually destroys the member; or inelastic action too small to be detected even by delicate static tests of material may by cumulative action cause serious damage under oft-repeated loading.

An illustration of the difference between static and repeated loading is furnished by the action of wire ropes bent around sheave wheels. The fiber stress due to bending is high and frequently causes inelastic action, which, however, is confined to a small portion of each wire. This inelastic action is very difficult to detect by means of static tests, but as the wire is repeatedly bent around sheave wheels this high local stress starts cracks which eventually cause rupture of individual wires. In this case, as in many others, the conception of perfect elastic action, allowable for static loading, must be discarded for repeated loads.

Materials Under Repeated High Stress.—For a range of fiber stress extending from the yield point of the material (for brittle materials the ultimate strength) down to a stress slightly lower than the elastic limit, as determined by laboratory tests of the usual precision, repeated stress will cause failure, and there seems to exist a fairly definite relation between fiber stress and the number of repetitions necessary to cause failure. This relation was pointed out by Basquin and may be expressed by the formula: $S = KN^q$, in which S = intensity of fiber stress in pounds per square inch, N = the number of repetitions of stress to cause failure, and K and q are experimentally determined constants. A similar relation was noted lated by Eden, Rose and Cunningham and by Upton and Lewis. Whether for still lower stresses such a law holds, or whether there is an "endurance limit" below which failure will not occur under any number of repetitions of stress, however many, is a question which will be discussed later.

Within the stress limits named above, if material is subjected to a cycle of stress involving application and removal of load, delicate measurements of deformation will show that the relation between stress and deformation is represented not by a single straight line, but by two curved lines, one for application and one for removal of load. Even if such deviation cannot be detected after a single cycle of stress it has been shown by Bairstow that the deviation may become appreciable after several thousand repetitions, and that the stress-deformation curve for a cycle of stress after a few repetitions becomes a closed curve resembling the "hysteresis" curves of magnetic material; the area enclosed by the loop represents energy lost during a cycle of stress, and this loss of energy is spoken of as "mechanical hysteresis."

If mechanical energy is dissipated during a cycle of stress it would seem that the lost energy must be transformed into heat, that there must be some form of internal friction in the material, that wear and structural damage take place, and that if the action is continued long enough the material will be ruptured. It would seem reasonable to consider the amount of structural damage during a cycle of stress to be proportional to the energy transformed into heat, or, in other words, to the area of the mechanical hysteresis loop. The shape of this loop remains similar to the shape developed under early cycles of stress.

The analytical discussion of the cumulative damage done by repeated stress seems to yield results in accordance with the results of tests, and is submitted as an explanation of the failure of materials under repeated stress within the stress limits named; that is, for stresses ranging from the yield point (or ultimate strength for brittle materials) down to a stress slightly below the "elastic limit" as usually determined in static tests.

Materials Under Repeated Low Stress.—As builders of machines have to design parts to withstand many times one million repetitions of stress, a problem of greatest importance is the determination of the action of repeated stresses lower than those considered in the foregoing paragraph. Is cumulative damage done under these lower stresses, and will they finally cause failure? Or is there an "endurance limit" below which no damage is done to the material, and below which the material will withstand an infinite number of repetitions?

*From a paper read before the American Society for Testing Material, June 26-28, 1915.

The latter view is the one which has been widely held, and the endurance limit has been regarded as coincident with the "true" elastic limit of a material. In favor of this view may be cited the fact that the number of repetitions of stress necessary to cause failure increases very rapidly as the fiber stress is lowered; that a number of tests have been made in which test specimens withstood tens of millions of repetitions of stress without failure; and that at low stresses, even with delicate measuring apparatus, there can be detected no signs of structural damage. Various methods have been used for determining the value of the endurance limit for a material; these different methods yield widely varying results.

In favor of the view that damage is done to materials under low stress and that there is a probability of their eventual failure under repeated low stress, the following considerations may be cited:

1. The occurrence of "slip lines" in metal under repeated stress seems to be the result of cumulative damage within a crystal of metal. No sharply defined lower limit has been found, either for the appearance of these slip lines or for their tendency to spread and develop into cracks.

2. The gradual development of permanent set, under repeated stress so low that preliminary static tests had shown no measurable set, seems to the writers to be an indication of damage at low stresses. This development is shown especially by the tests of Bairstow for cycles of stress not involving complete reversal. He found that the set for any stress gradually increased, though for a single cycle of stress no mechanical hysteresis could be detected; and that after several thousand repetitions the set did not further increase during the test. Whether this set would have shown further increase with an increase in the number of repetitions, or whether increase would have been shown by more delicate instruments, is an undecided question. In the opinion of the writers the significant fact is the cumulative development of permanent set under repeated low stress.

3. The sudden sharp breakages which occur in repeated stress tests, even of ductile materials, would seem to indicate that structural damage may be done to material without any undue deformation of the member as a whole. The fact that no undue deformation can be detected is no sure sign that a material is free from danger of failure under repeated stress.

4. Data of tests involving more than a million repetitions of stress are very few, yet frequently machine parts must be designed to endure several hundred millions of repetitions. The repeated stress problems of the time of Wöhler and Bauschinger were mainly problems of railroad bridge members and other structures and machines which would be called on to withstand only a few million repetitions of stress. From the viewpoint of these earlier investigators experiments under a few million repetitions covered the ground; for machines of to-day reliance on the results of such experiments involves enormous extrapolation of test results. The data seem hardly sufficient for establishing an endurance limit for infinite repetition, or even for repetitions numbering hundreds of millions. Moreover, the results of some tests, if taken alone, seem to indicate that some exponential law of endurance holds up to the limit of experimentation. These unusual tests are discussed later.

5. As instruments of increased delicacy are used in measuring deformation, evidences of mechanical hysteresis are found at lower and lower stresses in static tests. In actual material these evidences have been found at stresses not much above ordinary working stresses. When the cumulative action of repeated stress is considered, the indefiniteness of the elastic limit becomes apparent. While the statically determined elastic limit has some significance for static loading, it apparently has no significance as a criterion of endurance strength.

6. If elastic vibrations are set up in metal test specimens such vibrations soon die out. This dying out would seem to indicate loss of energy in heat, with accompanying internal friction, wear, and structural damage.

To the writers it seems that a negative argument against the use of a definite endurance limit is furnished by the indefiniteness of its determination. A common method of locating this limit is to plot from test a curve with stresses as ordinates and number of repetitions to cause failure as abscissas. The curve becomes nearly horizontal at a few millions of repetitions and the horizontal line to which the curve is asymptotic is judged by the eye. The ordinate of this horizontal line is taken as the endurance limit, and in this case gave a value of 18,000 lb. per sq. in.

Another method is to plot stresses (N) as ordinates and values of $1/N$ as abscissas. The endurance limit is taken as the ordinate of the intersection of this curve (extended) with the zero axis. This method, for the same test data as the first method, gives a value for the endurance limit of 17,500 lb. per sq. in.

A third method is to plot stresses as ordinates and some root of $1/N$ as abscissas. Using the fourth root of $1/N$ in the given test data, the endurance limit is found to be 15,000 lb. per sq. in. The eighth root of $1/N$ as abscissas gives the endurance limit as 7,000 lb. per sq. in. This series of tests involved one test at 19 million repetitions and one at 132 millions. If these various methods were applied to tests covering no more than one million repetitions of stress the results would show still greater variation.

Effect of Rapidity of Repetition of Stress.—A certain amount of time is required for any member of a machine or structure to assume the deformation corresponding to any given load, and if repetitions of load follow each other at intervals shorter than this time, the deformation in the member, the stress set up, and the number of repetitions it will withstand may be appreciably affected. A few recent British tests of material under repeated stress seem to indicate that for small members there is no appreciable effect produced by varying the rapidity of repetition of stress below about 2,000 repetitions per minute. Above that speed very little test data are available.

Effect of Rest on Resistance to Repeated Stress.—If metal is stressed beyond the yield point so that plastic action is set up, its strength and its elastic action are improved under subsequent stress, if the material is allowed to rest. Recent experiments by British investigators seem to indicate that, for steel and iron at least, the effect of rest on the resistance to repeated stress is negligible for unit stresses below the yield point of the material.

Effect of Sudden Change of Outline of Member.—Every sharp corner in a piece subjected to repeated stress facilitates the formation of micro-flaws in the piece. From results of repeated stress tests made by Stanton and Bairstow, at the British National Physical Laboratory, on test specimens of different shape, the superiority of the test specimens in which sharp corners are avoided is obvious. The relative values for strength under repeated stress for the shapes tested seems to be about as follows: Rounded fillet, 100; standard screw thread, 70; sharp corner, 50.

Service Expected from Various Machine and Structural Parts.—We do not know with certainty whether any material can resist an infinite number of repetitions of any stress however small. The safest view for an engineer to take seems to be that under repeated stress materials of construction have a limited "life." The exponential formula for repeated stress gives results in accordance with this view. If this view is held, the number of repetitions which any structural or machine member will have to withstand in normal service becomes of importance. The following list gives the numbers of repetitions of stress which may be expected to be applied to various machine and structural members. The list is intended to be suggestive rather than to serve as an exact guide.

The members of a railway bridge carrying 100 trains per day for a period of 50 years would sustain about 1,826,000 repetitions of stress. The stress would vary from the dead-load stress to a live-load stress averaging somewhat below that caused by the passage of the heaviest locomotives.

A railroad rail over which 250,000,000 tons of traffic passes would sustain something like 500,000 repetitions of locomotive wheel loads, the stress being slightly more severe than a repetition from zero to a maximum. The rail would have to stand, in addition to the locomotive wheel loads, something like 15,000,000 repetitions of stress caused by car wheel loads. The stresses set up by car wheel loads would be about half as great as the stresses set up by the locomotive wheel loads.

A mine hoisting rope bent over three sheave wheels and operating a hoist 100 times a day, in a term of service of five years would sustain 550,000 repetitions of stress. If the sheave wheels are so placed that they reverse the direction of the bending of the rope the range of stress would be nearly a complete reversal; if bending takes place in one direction only the range of stress is from nearly zero to a maximum.

The piston rod and the connecting rod of a steam engine running at 300 r.p.m. for 10 hours per day, 300 days per year for 10 years, sustains 540,000,000 repetitions of stress, and the range of stress involves almost complete reversal.

A band saw in hard service for two months sustains about 10,000,000 repetitions of stress varying from nearly zero to a maximum.

A line shaft running at 250 r.p.m. for 10 hours a day, 300 days per year, sustains during a service of 20 years 900,000,000 repetitions of bending stress due to force transmitted by belts, gears, and driving chains. The stress is almost completely reversed. It should be noted that for the line shaft the torsional stress is not repeated nearly so often as is the bending stress.

The shaft of a steam turbine running at 3,000 r.p.m. for 24 hours per day, 365 days in a year during 10 years' service sustains 15,768,000,000 reversals of bending stress caused by the weight of rotating parts and the tangential force of the inrushing steam.

In the United States Geological Survey Press Bulletin No. 233, Sept., 1915, it is stated that a ton of absolutely pure limestone would burn to a little over half its weight of lime, or about 1,120 pounds, which, counting 80 pounds to a bushel, would give 14 bushels of lime to a ton. The weight of the burned product, however, generally averages more than this, owing to impurities in the limestone, and also because in ordinary kilns the combustion is not complete enough to drive off all the carbon dioxide. A cubic foot of limestone averages in weight from 145 to 175 pounds, which would make a ton of limestone contain from 11 to 14 cubic feet.

BURSTING OF WATER TANK AT CANORA, SASKATCHEWAN.

The corporation of the town of Canora, Sask., suffered a loss on September 23rd, which crippled their fire protection and did considerable damage to their town hall and power station. The water storage tank which was located in that portion of the municipal building occupied by the electric light plant, burst while being filled with water, the unfilled portion containing air under pressure. The extent of the damage to the building and the tank itself is shown in the accompanying view. The tank was raised from its foundation and forced back about four feet. While half a dozen rivets pulled through the metal of the shell, the remainder held, thus tearing a strip from the end of the shell along the centre line of the rivet holes.

The cause of the accident was found to be due to the relief valve being badly corroded and the tension spring

Results of Explosion of Water Storage Tank at Canora, Saskatchewan.

filled with rust. This valve was so placed that the waste or overflow from other pipes discharged over the top of it, thus causing the heavy corrosion. The pressure gauge, too, shows heavy corrosion and is reported to have registered but 40 lbs. per sq. in. The relief valve was set at 100 lbs. per sq. in.

This tank, which is 9 feet in diameter and 38 feet long, formed a part of the Hoosier high-pressure system which was installed in 1912 for fire protection only. Similar systems have been installed for fire and domestic supply by the corporations of Yorkton, Wilkie, Melfort* and Old Battleford.

The town of Canora has now under construction a more complete system of waterworks which was designed by Messrs. Chipman and Power and which will be ready for initial test about October 15th of this year. The steel stand pipe which is being constructed for the new system is shown in the background of the photograph.

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*See *The Canadian Engineer*, January 29, 1914.

Editorial

OTTAWA-PRESCOTT HIGHWAY.

On October 4th the Ottawa city council voted in favor of the Ottawa-Prescott highway, as projected by a number of municipalities, to be constructed in accordance with the provisions of the new Highway Act of Ontario. The council further resolved to petition the Lieutenant-Governor-in-Council to appoint a commission to carry the undertaking through to completion as soon as possible.

The animated progress of the scheme subsequently received a set-back when it was found that the Highway Act had not yet been made law. This important fact was communicated to the council by Mr. W. A. McLean, Provincial Engineer of Highways for Ontario. Obviously, there will be a reconsideration and a more thorough preliminary investigation.

For months the forces of the Ottawa-Prescott highway scheme and the forces of the Ottawa-Morrisburg highway scheme battled away for a decision on points. The referee, if one may venture the appellation on the sometime attentive municipal body, appeared to have left his stop-watch at home. The advocates of the Prescott route made an unrecoverable gain, however, when it presented the Board of Control with a petition carrying the signatures of over 500 of Ottawa's leading citizens and representing over 50 per cent. of the local assessment of the city. This petition asked that the board send the highway proposal along to council and adopt the Prescott route as superior to all others proposed.

This road, when constructed, will extend from Ottawa to the international boundary through the towns of Nepean, Kemptville and Prescott. Ogdensburg, whose leading citizens took a prominent interest in the contest, is connected with Prescott by a ferry, and Ottawa has high hopes of an extensive tourist traffic to and fro, with a straight run of 400 miles to New York City.

The cost of the proposed road is about $600,000, of which Ottawa will pay $180,000. The route chosen is 58 miles long. The rival Morrisburg project, with a contemplated ferry across to Waddington, would have cost Ottawa about $150,000, if adopted, owing to its smaller mileage.

FORT WILLIAM AIMS AT BETTER MUNICIPAL SERVICE.

The city of Fort William, Ont., has established a Municipal Officers' Association that will undoubtedly facilitate a better understanding of municipal affairs among those in whose hands the government of the various departments rests. Membership is open to all department heads of the city and district and to such other municipal officials as may from time to time be considered eligible. The association holds regular monthly meetings and maintains a number of committees, whose activities cover well the entire sphere of municipal affairs. Its objects are chiefly:—

(1) To encourage the study and promote a knowledge of the principles of municipal government.

(2) To provide means of and to encourage social intercourse amongst the members for their improvement and benefit.

(3) To deal with matters relating to the status of members.

(4) To invite the formation of similar associations in other municipalities.

Among the various committees appointed there is a municipal management committee, whose duties are adequately indicated in its name. This committee has power to deal with all matters relating to policies referred to the association from time to time by the city council.

This organization as a whole is a progressive step that should invite the investigation of municipalities at large. As one of its objects is to invite the formation of similar organizations, the association will no doubt be attentive to all enquiries. Its secretary is Mr. R. R. Knight, city engineer, Fort William.

CANADIAN ARMY HYDROLOGICAL CORPS.

The present war has called forth many new ideas and organizations, each of which has a place and an object in our national life and struggle. But there is one theme pre-eminent in our minds: that is, the duty of national service. France of 1870 has been changed into France of 1915 by the clarion call to service, but it was only in recent years that French patriots succeeded in convincing the people of the imperative duty that they should undertake. The spirit of the Crusaders has gripped Britain, and everything is being sacrificed at the altar of national service. Belgium has suffered martyrdom in the cause of national service. Canada has imbibed freely of the same sublime spirit, and her sons have exhibited ability and valor equal to any on the battlefield.

But we cannot all fight, and yet assuredly in the hour of tremendous struggle there is some service that we can perform. Armies are composed of many branches of service, all of which are important and inter-dependent. At one time it was a popular belief that armies fight on their stomachs, but to-day we know that armies are vastly more efficient if they are healthy and vigorous. Almost every war has seen the sacrifice of battalions because of sickness which was preventable, and the present conflict is a singular proof of the possibility of conducting a war and yet of holding the carrions of disease at bay. Serbia and Austria, however, have suffered terribly from defective sanitary administration, and this exception serves to prove that disease is ever at the gates awaiting an opportunity to attack.

The work of attending to the sanitary requirements of the British Army is in the hands of the Army Medical Corps and the Royal Engineers. In Canada there is another organization called the "Canadian Army Hydrological Corps and Advisors on Sanitation." The name suggests one of its primary functions to be finding and restoring the purity of water. This is the premier requirement of an army. Practically every other kind of sanitary work is under effective control. Filth can be disposed of effectually and without causing danger; the work can be inspected frequently, and if any neglect takes place it can usually be observed. But with water supplies the dangers are more subtle, often unobservable. Still, neglect or inefficiency in the past has caused the loss of thousands of lives and will again produce disastrous results. Often when the army was engaged in important movements men were stricken with illness, epidemics burst with violent abruptness, as at Bloemfontein, and the forces were compelled to postpone their attacks, for even if the soldiers were not all in hospital, the majority of them were probably suffering in a mild way. One healthy soldier is assuredly worth more than ten sick ones, and consequently it pays to preserve the health and conserve the lives of the men by maintaining the purity of the water supply and the sanitary condition of the camps. Canadian camps are fortunate that their health bill has been excellent. The water supplies have been carefully watched, usually by members of the Hydrological Corps, to whose efforts are due in a great measure the good health of the soldiers, and also the consequent increase in their vitality.

While the Canadian Army Hydrological Corps and Advisors on Sanitation are recognized by the Militia Department and their services are utilized in a limited way, it is felt that the potential value of the corps has not been appreciated by the Department, but that its attitude is rather one of benevolent passivity. This situation is one to be regretted, for the Corps, if properly recognized and employed, will develop into a most practical and valuable branch of the military service by virtue of the fact that it is composed of men who are well qualified in their respective professions.

Lt.-Col. Nasmith is the chief of the Corps, and is engaged in France on water examinations. Major Woodhouse is second in command. There are at present fifteen captains, all of whom are well known in connection with sanitary work; for example, Mr. F. A. Dallyn, C.E., the Provincial Sanitary Engineer of Ontario; Mr. A. V. Delaporte, B.A.Sc., Mr. J. Race, Mr. G. H. Ferguson, B.A.Sc., are familiar names to our readers.

We are profoundly of the opinion that Canada should take a prominent position in the organization of a corps of technical men in connection with the military forces, both at home and on the battlefields. Every encouragement should be extended to men to place their services at the disposal of the nation, and their individual and specific experience, training and talents should be utilized to the utmost possible extent. It would manifestly be unwise to employ an experienced chemist and bacteriologist to handle the rifle when he could, by means of his scientific training, render greater assistance in conserving the lives of numbers untold from the ravages of preventable disease. Moreover, as medical men are so urgently needed—it is reported that even alien doctors are invited to render service—it would appear strange to employ them on sanitary work when sanitary engineers could attend to it quite as effectually. The employment of technical men in connection with military operations in capacities which will draw the very best service is advocated; and furthermore, the experience and knowledge gained by such men under the varied conditions of warfare will be invaluable to the country in time of peace.

When the conflict ceases there will be a gigantic task of reconstruction. Will Canada lend her aid by placing the services of her technical corps at the disposal of the governments concerned? It must not be assumed that because under rigorous military discipline a high standard of sanitation has been maintained that the same condition will be possible under the less rigorous civil administration. Canada will doubtless be called upon to help to re-establish the civil life in the frightfully devastated countries, and every Canadian will be proud of her ability to do her share in the reconstruction of the countries which have suffered so sadly by this war.

We hope that the Hydrological Corps will be permanently established, that men trained in engineering, chemistry, bacteriology, sanitation and other allied sciences will constitute its strength, and these men, fortified by their military experiences, equipped with knowledge gained under varied and peculiar conditions, with visions enlarged by intimate contact with their compeers in service, will be of still greater value as public servants when they return to their normal vocations.

MONTREAL'S MUDDLED WATERWORKS.

The Council of the Canadian Society of Civil Engineers has sent a second letter to the Montreal civic officials relative to the waterworks extensions proposed by the latter. In our issue of August 12th, 1915, the attention of our readers was called to the Society's first letter, urging the authorities to have the project reported upon by a board of independent engineers before incurring further expenditure. The system had already cost the city over five millions and the present scheme which, if carried out, would raise the amount to nine and a half millions, or more, is such as to command at the very least, a more authoritative and painstaking investigation than has been given it.

Before presenting the text of the second letter of the Society, whose admirable stand in the matter merits the sanction and approval of all who desire to safeguard the interests of the profession against the derogatory influence of irresponsible civic authority, it is interesting to review the events that have transpired since the reference to the subject in our issue of August 12th. There it was noted that two protests were launched, one by the Council of the Canadian Society of Civil Engineers and another by Mr. J. A. Jamieson, a Montreal consulting engineer, and a former member of the board which investigated the water supply trouble in 1914. These two protests had no relation whatever to each other. Mr. Jamieson apparently did not know that the Council of the Society had the question in hand, and the Council was not aware that Mr. Jamieson was taking it up. However, both expressed the same desire, namely, that the scheme should at once be reported upon by competent engineers.

It so happened that both protests reached the civic authorities about the same time. Evidently the city hall suspected collusion, for in due time the communication of the Council of the Society was acknowledged, enclosing as an answer to its urgent appeal, a copy only of the open letter which Controller Cote had published in the papers in reply to Mr. Jamieson. The text of Mr. Cote's letter, let it be stated, carried meagre conviction, and the technical points raised therein comprised nothing of value that was new. It is an interesting sidelight that Mr. Cote relied on the approval of Mr. Ernest Marceau, a member of the Society Council, who publicly repudiated Mr. Cote's statement in the Montreal press. But in recognition of the interest of the Council of the Canadian Society of Civil Engineers, in the whole project, the board of commissioners of the city extended themselves to the limit outlined above, *viz.*, a copy of the letter to Mr. Jamieson.

Following is the second letter, dated October 7th, transmitted to the mayor and members of the board of commissioners and to the members of the city council of Montreal by the Council of the Society:—

Gentlemen,—On July 29th the Council of the Canadian Society of Civil Engineers addressed to your Board a letter suggesting that you stay the expenditure of public money on the waterworks enlargement until the whole project has been examined and approved by a board of independent engineers. The communication from this Society was read at a meeting of your Board held on August 3rd, 1915, and it was proposed by Commissioner Cote, seconded by Commissioner Hebert, to officially transmit to the Canadian Society of Civil Engineers a copy of a letter written on the same subject by Commissioner Cote and addressed to Mr. J. A. Jamieson.

While the Council of this Society cannot undertake to discuss the technical points raised in Commissioner Cote's letter, it takes exception to the following paragraph contained in the communication to Mr. Jamieson: "Notwithstanding the many favorable reports prepared by the engineers during the past quarter of a century and the more recent decisions arrived at since the beginning of the scheme of enlargement in 1907, all favorable to the carrying out of the works, you persist in coming forward to plead against the whole scheme as not being to the commercial advantage of the city." This Council's exception to the foregoing quotation is that the work therein referred to is essentially different from the project now begun. The project contemplated in 1907 was for a minimum development of 2,000 h.p. at low water with mid-winter ice conditions, and it was not until November, 1910, that Mr. Janin* submitted to the Board of Commissioners the project which is now partly under way. This project includes the construction of large filtration works, the construction of a hydro-electric plant of 10,000 h.p. capacity, and the widening and deepening of the aqueduct. The enlarged aqueduct is to carry the water necessary for the domestic supply of the city in addition to that required to operate the water-wheels of a 10,000-h.p. development.

From Commissioner Cote's letter to Mr. Jamieson, the Council understands that your Board is under the impression that the complete project has been approved by the engineers named in the letter above referred to, and that such approval as has been given is sufficient to warrant the city in incurring the expense of the construction of the proposed works. Of the gentlemen mentioned, Messrs. M. J. Butler, George W. Fuller, G. R. Heckle, Rudolph Hering, J. A. Jamieson, John Kennedy, R. S. Lea, Ernest Marceau and J. E. Vanier are not on the staff of the city, but as they are members of the Canadian Society of Civil Engineers this Council deemed it proper to ask each of them to define the scope of his investigation and to communicate his findings with regard thereto. These inquiries have been duly answered. The Council learns from the statements thus obtained that no one of the engineers referred to has taken up the subject as a whole or studied it in any way which would enable him to judge of the merits of the complete undertaking. Further, the replies show that the professional work done and opinions given was in connection with isolated parts of the present project, or in connection with proposals essentially different from the project now begun.

*At that time City Engineer of Montreal.

In the light of this information the Council of the Canadian Society of Civil Engineers again respectfully urges that its suggestion be carried out without delay, namely, that the whole project be reported upon by a board of independent engineers before further expenditure is incurred. In laying this matter before your honorable body for the second time, this Council would urge the necessity for such a report in the interest of every engineer who has been connected with the project, the good name of the engineering profession, and in the interest of every ratepayer of the city of Montreal.

I have the honor to be,

Yours very truly,

(Signed) C. H. McLEOD,
Secretary.

LETTER TO THE EDITOR.

Street Cleaning By Dry Method.

Sir,—I was interested in reading your short article on street cleaning by dry method in your issue of September, 23.

The dry method has been adopted in this city for the past two years and we have found it very satisfactory. I am quite satisfied that it will result in increasing the life of the pavement. We use nothing but the patrol system with hand brooms and pick-up cans. The cost last year was 16½ cents per thousand square yards.

I feel satisfied this system will be more generally introduced when engineers find the resultant benefit.

Yours truly,

C. H. RUST,
City Engineer.

Victoria, B.C., October 9th, 1915.

THE THERMO-ELECTRIC PROPERTIES OF CARBON.

The Journal of the American Chemical Society publishes a paper by W. C. Moore, dealing with the thermo-electric properties of carbon and offering evidence from a new viewpoint that amorphous carbon is not a single definite substance. The thermo-electric properties of this material are reproducible for any one carbon, but they may vary with the temperature and are determined by the kind of raw material used and the manufacturing history of the carbon. The fact that with some varieties of arc carbons a considerable temperature range of constant electromotive force was found indicates the possibility of a transition interval for these carbons.

Train mileage on British railways was nearly 5½ million miles less in 1914 than in 1913. Goods mileage fell from 161,684,000 to 156,007,000, and mixed mileage from 672,000 to 666,000. Passenger mileage, which, of course, includes troop trains, increased from 173,495,000 to 273,659,000. Coaching shunting miles increased from 18,665,000 to 18,910,000, goods shunting miles fell from 119,142,000 to 116,110,000, while mixed shunting miles increased from 58,000 to 59,000. Other mileage—assisting, light running, etc.—also increased from 54,608,000 to 55,828,000, but the total engine mileage had a decrease of seven million miles—621,239,000, as against 628,-324,000 in 1913. The total receipts in 1913 were £139,451,000 and the expenditure £87,320,000. In 1914 the receipts—including the estimated amount receivable from the Government—were £139,098,000 and the expenditure £88,173,000.

COAST TO COAST

Winnipeg, Man.—The Main Street subway was opened for traffic last week.

Nelson, B.C.—The Payne mine has completed a tunnel about 3,700 ft. in length and with a 720-ft. rise.

Victoria, B.C.—Foundations for the main building of the new observatory have been completed and a water reservoir constructed.

Hope, B.C.—The Kettle Valley Railway has been completed between Hope and Ladner Creek. Over the latter a steel bridge is being constructed.

Peterborough, Ont.—The new asphaltic concrete pavement on Charlotte Street West has been completed, and the paving of Park Street is under way.

Montreal, Que.—At the annual meeting of the Canadian Pacific Railway shareholders on October 6th, a resolution was adopted empowering the company to absorb the Allan Steamship Company.

Calgary, Alta.—The irrigation engineers of the Canadian Pacific Railway are undertaking extensions into the Taber district, a part of the company's irrigation block. Preliminary work, including topography, hydrography and cost of proposed ditches, is being proceeded with.

Toronto, Ont.—The plans for the new Union Station were submitted to the city architect last week by the Toronto Terminal Company. The expenditure provided for by the plans is $3,340,000, an increase of $340,000 on the original estimate. The viaduct and approaches to complete the railway development along the water front are estimated to cost about $12,000,000.

Fort William, Ont.—The new addition to the Fort William coal docks has been completed, increasing the capacity to 150,000 tons of coal. The work was carried out by the Brown Hoisting Machinery Company, of Cleveland, Ohio. The superintendent of construction was Mr. P. W. Peterson. A $200,000 addition is now contemplated for the Mission River plant.

Montreal, Que.—A good grade of natural gas in large volume has been discovered at St. Barnabe, a small village eight miles west of the city of St. Hyacinthe, and about 35 miles east of Montreal. The National Gas Co. of Canada, largely composed of Ottawa and Montreal capitalists, has secured the gas rights. A pressure of 400 pounds per square inch has been found at a depth of 1,520 feet.

New Liskeard, Ont.—It is rumored that another large pulp and paper mill is to be built in the Timiskaming district, about 30 miles west of Cochrane. Messrs. Sutcliffe & Neelands have had charge of preliminary investigations. The proposed site will necessitate the construction of about three miles of railway to connect the plant with the National Transcontinental. It is estimated that $2,000,000 will be spent on the development.

Ottawa, Ont.—The members of the International Waterways Commission held a session in Ottawa last week. Several important cases came up for disposition. The St. Croix water power and Sprague Falls Manufacturing Company's dispute regarding water rights on the St. Croix River was dealt with. The province of New Brunswick asked at the last session, in June, that the interests of the province be fully protected. An engineering report, made up by American and Canadian representatives, has been completed and was considered on October 7th. The dispute arose out of the diversion of the water from the St. Croix River to Grand Falls. Under the treaty governing boundary waters, the waters of boundary rivers are to be divided. The levels of the Lake of the Woods were again considered. The report in this investigation is a voluminous one, and is expected to be ready next year. Another question which was taken up is the measurements and apportionment of the St. Mary's and Milk Rivers. Both rivers rise in Montana and flow into Alberta. The Milk River flows back into Montana. As both rivers are used largely for irrigation purposes, they are considered as one river. All the members of the commission, both American and Canadian, were in attendance.

PERSONAL.

W. B. REDFERN, B.A.Sc., has resigned his position as town engineer of Steelton, Ont.

DANIEL BREAK, who has had charge of the electric light and waterworks plants of the town of Ridgetown, Ont., has resigned.

GEORGE CHAHOON has been elected president of the Laurentide Company, Limited, in succession to the late Sir William Van Horne.

M. FERGUSON, city engineer of St. Thomas, Ont., has had added to his duties the supervision of all construction work of the city gas department.

W. R. FITZMAURICE, formerly assistant superintendent of District No. 2, Intercolonial Railway, succeeds the late Mr. Evan Price as acting superintendent, with headquarters at Campbellton, N.B.

C. H. FULLERTON, O.L.S., of New Liskeard, Ont., a civil engineer and surveyor well known in Northern Ontario, has been appointed superintendent of colonization roads in Ontario, succeeding Major W. H. Bennett, who lost his life at St. Julien. Mr. Fullerton is a graduate of the University of Toronto.

R. F. HAYWARD, general manager and chief engineer of the Western Canada Power Company, and chairman of the Vancouver Branch of the Canadian Society of Civil Engineers, attended in person the monthly meeting of the Society in Montreal on October 7th and read a paper on "The Stave Falls Power Development of the Western Canada Power Company, Limited," an abstract of which appeared in last week's issue.

OBITUARY.

The death occurred at Niagara Falls, Ont., of Mr. F. F. Wood, one of the promotors of the proposed Owen Sound dry dock scheme.

At St. Mary's, Ont., Mr. Harry R. McEvoy, C.E., died on October 3rd in his 67th year. The deceased was a surveyor of wide experience, and spent many years in the service of the Dominion Government.

The death occurred in Toronto last week of Mr. John Patrick, for many years superintendent of the Parkdale section of the Toronto waterworks department. The deceased was in charge of the construction of the waterworks system of Parkdale when it was installed many years ago.