raising fire pressure without additional steam-power.

The distribution pipes are of cast iron, and are from 20-in. to 6-in. diameter. About 27 miles are now in use and 280 hydrants.

The works were built after the plans and under the superintendence of Galen W. Pearsons, C. E.

No publication has been made of the expenditures and revenue of the company owning the works. The superintendent is B. F. Jones.

XXVIII.—CAMBRIDGE.

Cambridge, Mass., is separated from the City of Boston by the Charles River. It was founded in 1630. In 1855, the population being about 20,000, a private company constructed water-works, taking their supply from Fresh Pond, a natural lake of 188 acres area, receiving the drainage of 569 acres. No streams flowed into the pond, which was partly within the city limits, until 1880, when the whole pond and its borders were transferred to the city. It discharges its surplus water through Alewife Brook.

The works were purchased by the city in 1865. In 1876, additional water was procured by building a conduit of wood and brick of 10.65 sq. ft. sectional area and 4,061 ft. long to Spy Pond, Little Pond and Wellington Brook. The waters of the two last named can only be used at certain seasons, on account of their pollution during most of the year. Fresh Pond is capable of supplying one and a half millons per day in dry weather. When more than two million gallons per day have been pumped from it, there has been a constant lowering of its surface without recovery. A filter gallery was also built in 1876, beyond Wellington Brook, which yielded 400,000 gallons per day for 63 days in 1880. The supply in 1880 was so deficient that a pump was placed at Fresh Pond with the intention of pumping into the supply conduit and lowering the pond below the conduit level, in case of a continuance of the dry season. Efforts were also made to obtain a supply from the Mystic Water-works of Boston, but those works were in the same condition of deficient supply for their own consumption at that time. A connection with the Boston pipes was made, however.

A supply conduit leads from the pond to the engine-house, where two Worthington engines were erected in 1855, each of 720,000 gallons per day capacity.

In 1868 a compound Worthington engine of five million gallons capacity was added, and in 1874 another of the same capacity was built and a new 48-in. supply conduit laid from the engine-house to the pond, 5 ft. below the old one, which was then removed.

The first force main was of 12-in. diameter. From the first large engine another was laid of 24-in. diameter, and in 1873 another of 30-in. diameter. The engines pump into a stand-pipe which is 122.7 ft. above tide marsh level, with an overflow at 120 ft.

The first reservoir is on the highest ground in the city, 2,800 ft. from the engine-house, and its water surface is 73.4 ft. above the pumps. It is 165 ft. square and 10 ft. deep. Its slopes are paved with stone. Another reservoir was built adjoining this in 1868.

The original reservoir leaked badly on being first filled, and extensive repairs were required before it became able to hold water. The retaining walls outside of the reservoir banks and the partition wall between the reservoirs have given much trouble. In 1878 a large amount of rebuilding and patching of walls, and pointing and grouting and paving, was necessary.

The distribution pipes originally laid were of wrought iron and cement. Cast-iron pipe are now used. A large proportion of the pipes are of small sizes.

On Dec. 1, 1880, there were 7,322 taps. Service pipes are now laid of galvanized iron with brass fittings and with shut-off at the sidewalk, and are laid from the main to the cellar of the house by employés of the Water Board. Five hundred and seventy-nine fire hydrants are in use, of which 240 are post and 339 flush hydrants. No new flush hydrants have been set since 1873, and many have been replaced by post hydrants. Meters have been in use since 1870. The present number is 156. The average daily consumption in 1880 was 2,423,220 gallons, and the population 52,740.

The works are controlled by a board composed of the Mayor, the President of the Common Council and five citizens. The superintendent from 1871 to 1877 was S. W. Dudley, and from 1877 to 1881, Hiram Nevons. The City Engineer, Mr. W. S. Barbour, superintends works of construction and advises the Board when called on.

The total cost of the works to Nov. 30, 1880, was $1,721,830.54. The revenue from water rents from April 28, 1865, when the city purchased the works, to Nov. 30, 1880, was $1,864,755.31.

The outstanding bonded indebtedness is $1,528,-500 to provide for the payment of which there is a sinking-fund which now amounts to $414,568.48.

XXIX.—FALL RIVER.

Fall River, Massachusetts, is in lat. 41° 42′ 3″ N., long. 71° 9′ 37.5″ W., on the eastern side of Mount Hope Bay, an arm of Narragansett Bay. The city comprises 27.5 square miles.

The topography is irregular, the ground rising at some points to 260 ft. above tide level.

It was settled in 1659 and incorporated as a city in 1854. In 1870, the population being 26,766, the construction of water-works was decided upon, and a report made by W. J. McAlpine, C. E. In 1871 the works were begun, with George A. Briggs as chief and James P. Kirkwood as consulting engineer.

Water is taken from Watuppa Lake, 2 miles east of the city, which has an area of 5.5 square miles. Its storage capacity is ten thousand million gallons, and its surface is 128 ft. above tide water. Its mean daily discharge is estimated at 35 million gallons, and furnishes the water power which first attracted manufacturers to the town.

On the west shore of the lake 9,472 ft. from the main street of the city, the engine-house was built. To avoid heavy rock excavation on the steep banks, the building was placed 60 ft. from the shore in the lake. A coffer dam, composed of two rows of sheet piling 10 ft. apart, was built on the ice in winter and lowered to place. The material within the dam was excavated to rock in some places and in others the bottom was covered with 18 in. of concrete, on which the foundation walls were built.

From a gate-house 10 by 8 ft., its floor being 10 ft. below the lake surface, an arched conduit, 6 ft. wide and 4 ft. high, conducts the water to the engine-house, there dividing into 4 branches, one leading to each of 4 pump wells, whence it is pumped.

The first engine was a double horizontal condensing engine, with steam cylinders 28-in. and pumps 16-in. diameter and 42-in. stroke, coupled to a fly wheel shaft and arranged to work separately or together. Its nominal capacity is three million gallons per day, and at 24 strokes per minute can pump 4,750,000 gallons per day. The duty of this engine was not equal to the contract requirements, and after an arbitration $1,400 was deducted from the price named in the contract for its construction. It began pumping in January, 1874.

In 1875 a Worthington engine of five million gallons capacity was erected.

The engines pump into two stand-pipes; the low-service are 31.3 ft. high, its top being 280 ft. above tide level, and the high-service pipe 78 ft. high, with a weir opening 23 ft. below its top. A stone masonry tower 116 ft. high incloses the two stand-pipes.

The high-service distribution includes about one-quarter of the city.

Distribution pipes are of cast iron, coated with Dr. Smith's preparation.

Meters have been used from the beginning of the works, and in 1880 1,878 were in use, supplying about 62 per cent. of the consumers. The consumption is 1,263,923 gallons per day, and the population 49,006. The cost of the works to Jan. 1, 1880, was $1,432,906.11, and the receipts from water rents to the same date had been $293,264.96.

Five commissioners had charge of construction until 1874, when the works were placed in charge of the Watuppa Water Board, composed of three commissioners holding office for three years, one retiring each year.

George A. Briggs was chief engineer until December 31, 1874, after which date William Rotch was chief engineer and superintendent until De-December 31, 1880, when he was succeeded by William Carr, Jr.

XXX.—RICHMOND.

Richmond, Virginia, is in lat. 37° 32′ 17″ N., long. 77° 27′ 28″ W., on the north side of the James River, 151 miles from its mouth, at the head of tide water. There is a rapid descent in the river at this point which affords a head which is utilized for water power. The site of the city is on a cluster of hills.

Settled in 1609, its population in 1830 was 16,060, when water-works were built after the plans of Albert Stein, C. E., taking their supply from the river. A breast wheel 16 ft. diameter and 10 ft. wide drove a horizontal double-acting piston pump of 10-in. diameter and 72-in. stroke, which forced the water through 2,400 ft. of 8-in. pipe to a reservoir 166 ft. above the river. In 1834 another wheel and pump of the same size were added, and in 1854 two more pumps of 12-in. diameter and 72-in. stroke were put up. In 1874 a Jonval turbine of 9 ft. diameter, working under 10 ft. head, was erected, driving two horizontal double-acting pumps of 17-in. diameter and 72-in. stroke, which forces the water into a new reserv ir 203 ft. above the river. During the interruption of the supply from construction of these pumps, a Guild & Garrison steam pump of 12-in. diameter and 36-in. stroke was used to lift water from the James River and Kanawha Canal, 43 ft. above the water pumps. The steam pump is also used to aid in supplying water during freshets or low water.

In 1880 the water-power machinery was increased by a vertical turbine, after the plans of Charles A. Smith, C. E., which were selected from several competitive designs offered. The supply is still very defective, and for several weeks in the summer of 1880 about half the city was without water, and at one fire, at least, all that the firemen could do was to stand by and see the building burn. The water is highly charged with sediment, which settles very slowly. Samples left undisturbed for three months retain a decided color.

The first reservoir, built about 1831, was in two compartments, each 194 by 104 ft. and 10.7 ft. deep. A gravel filter bed was attached to each division, but they do not appear to have worked successfully. The reservoirs were of earth embankment, with a puddle core in the centre, and the slopes were lined with four inches of brick on edge laid diagonally on the slope. The bottom was paved with one course of brick flatwise, laid in lime mortar.

In 1844 the embankments were raised 6 ft., and the water surface made 256 by 382 ft. at 166 ft. above the pumps. In 1876 there were reported 6 ft. of mud in the bottom, which could not be removed by drainage. The influent and effluent pipes pass through the banks, with no gate houses.

The available capacity is 8 million gallons. The new reservoir, built 1874-5 is of earth embankment and has two divisions, each 416 by 426 ft. at water surface and 20 ft. deep, and containing 20 million gallons. It is provided with a masonry influent and effluent chambers, communicating with either division at will, and has a settling space below the low-water draught line, with arrangements for draining of the sediment. The slopes are 2 to 1 and lined with one course of brick on edge laid in cement mortar. The bottom is covered with six inches of concrete.

Distribution pipes are of cast iron. Uncoated pipes have lasted well for 40 years. There is a great proportion of small pipe in use. About 60 miles are laid. Meters are not used. There are about 6,200 taps.

The original works cost $95,000. The total cost to 1880 has been, including maintenance, about $2,500,000. The annual expenses are about $30,000.

A committee of the City Council manages the works, through a superintendent, the city engineer having charge of works of construction. The city engineer is W. E. Cutshaw and the superintendent H. C. Richmond.

(TO BE CONTINUED.)

SOUTH AMERICAN ENGINEERING NEWS.

A telegram from Pernambuco announces the opening of tenders for the construction of a railway from Timbaúba to Goyana. Only three proposals had been received, as follows: Messrs. Wilson Sons & Co., requiring an interest guarantee of 7 per cent. per annum for thirty years on the sum of 40,000$ per kilometer; Sr. Costa Carvalho, requiring a similar guarantee for twenty-five years on 50,000$ per kilometer; and Messrs. Snell, Read & Bowen, requiring only the privileges conceded by law, and dispensing with the guarantee.

The representative of Siemeur, Kermos & Co. has applied to the municipality proposing to illuminate the Plaza Victoria, and some of the principal streets in Buenos Ayres, with electric light. The lamps would have to occupy places now filled with gas lamps, and the electric machine in the *patio* of the Cablido. The strength of the light is represented as 350 stearine candles, or 17½ gas burners, per lamp. At present it is proposed to put up twelve lamps.

The club of engineering lately founded at Rio Janeiro proposes to have some of the best works on engineering subjects translated into Portuguese.

The club has sketched out an immense programme, being no less than to furnish statistical and other information of the whole industrial world of Brazil. They intend also to publish an annual, which will certainly be valuable if the "plan" is carried out.

CORRESPONDENCE.

CHAUDIERE BRIDGE.

TORONTO, June 27, 1881.

EDITOR ENGINEERING NEWS:

It is stated in your narrative of the Chaudière Bridge, at Ottawa—Vol. VIII., No. 24—that the floor system is of a design not in use before the construction of that bridge. This is not correct.

The floor system mentioned is a design adopted by the Grand Trunk Railway in the year 1877.

T. D. H.

ONE HUNDRED FEET TAPE.

ERIE, Pa., June 24, 1881.

EDITOR ENGINEERING NEWS:

M. J. Wells asks for a strong tape one hundred feet long. I have an excellent one, made by Young & Sons, Philadelphia. It has often been passed over by a wagon, and is not yet broken. The one I have is only graduated to feet. For a pocket tape divided to hundredths, I prefer a Paine to a Chesterman, as they are much less easily broken.

W. W. BRIGDEN, City Engineer.

MANKATO, Minn., June 21, 1881.

EDITOR ENGINEERING NEWS:

Say to your correspondent, M. J. Wells, that he will find the chain tape manufactured by Young & Sons, Philadelphia, what he wants. I have been using one the past year, and consider it the best measuring line I ever saw. It is light, accurate and durable.

M. B. HAYNES.

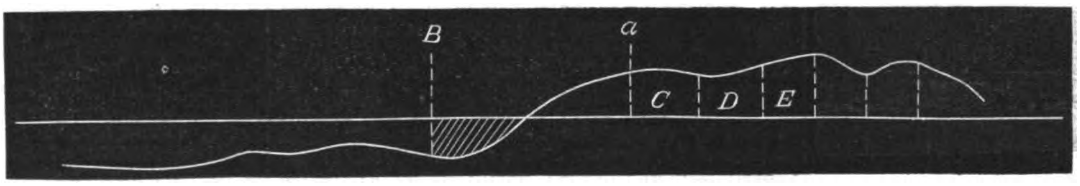
AVERAGE HAUL.

CLEVELAND, O., June 22, 1881.

EDITOR ENGINEERING NEWS:

The inclosed figure may be of some assistance to "Resident Engineer:"

It becomes necessary to determine the excess when work has been carried on until material taken from the cut at A and deposited in bank at B must be moved more than 300 feet.



Let $C\ D\ E$, etc., represent the number of cubic yards in the succeeding stations, which are here assumed to be of equal length.

Observing that the center of the mass C is approximately half a station, and that of the mass D one and a half stations from the point A, use the simple form,

$$\frac{\frac{1}{2}C + 1\frac{1}{2}D + 2\frac{1}{2}E + etc.}{C + D + E + etc.}$$

to determine the distance (m) from the point A to the center of gravity of the excess $C\ D\ E$.

In like manner find the distance (n) from the point B to the center of gravity of the same number of yards when placed in an embankment, and $m + n$ will equal distance for which "extra haul" on the excess should be computed. Sub-contractors will doubtless call "Resident Engineer's" attention to the "fact" (?) that it will be much cheaper for the company to permit them to waste and borrow than to fix such distances that $(m + n)$ 1c. will become nearly equal to the contract price for earthwork.

D.

AVERAGE HAUL.

[If "Resident Engineer," who had an inquiry under the above title in ENGINEERING NEWS of June 18, will send his address to Bates & Auchincloss, No. 209 Church street, Philadelphia, he will receive pamphlets bearing upon the subject.—ED. ENG. NEWS.]

FORMULAS FOR TURNOUTS.

KOKOMO, Colorado, June 15, 1881.

EDITOR ENGINEERING NEWS:

Since there seems to be some interest manifested upon the subject of frog distances, through the later issues of ENGINEERING NEWS, I desire space in your columns to present some formulas for their generality, as being formulas, not only for the determination of frog distances under the usual conditions of turnout from tangent or curve, with a curved lead rail, but for determining those distances where a portion of the lead rail, next to the frog, is desired to be straight. I make use of letters in referring to all lines and quantities, in the accompanying diagrams, for the sake of generality; such letters as those representing gauge, throw

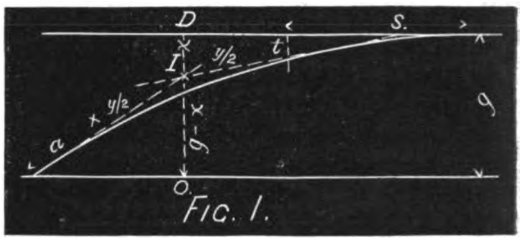


FIG. 1.

and slide rail would, upon any one railroad, have a constant value, thereby rendering these formulas much more terse than they seem with operations merely indicated.

Referring to the diagrams,

s = loose part of slide rail.
t = throw.
y = sum of the dotted semi-tangents to curved part of lead rail.
a = straight portion of lead rail.
g = gauge of track.
b = No. of frog.
and x = distance between tangent rail through point of throw, and the intersection, I, of the semi-tangents, y.
$D\ O$ = distance between tangent to point of throw, and tangent to point of frog measured on a line passing through I, being on a straight main track, as in fig. (1), coincident and equal with $F\ E$, which represents the gauge (g) measured through I.

In fig. 1,

$$x = \frac{ty}{s} + t \text{ and } g - x = \frac{a}{b} + \frac{y}{2b}$$

or,

$$x = g - \frac{a}{b} - \frac{y}{2b}$$

If we eliminate x by comparison of these two equations we have

$$\frac{ty}{s} + t = g - \frac{a}{b} - \frac{y}{2b}.$$

which, when reduced, becomes

$$y = \frac{bs(g-t) - sa}{bt + \frac{s}{2}} \quad (1).$$

Suppose now we want to use a No. 8 frog, our gauge is 3 ft., throw 5 in., the unspiked portion of

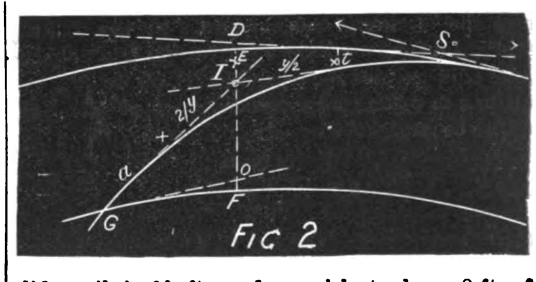


FIG 2

slide rail is 20 ft., and we wish to have 8 ft. of straight lead for drives to straighten out on as they approach the frog; substituting these values in equation (1), we have

$$y = \frac{253.44}{13.33} = 19;$$

that is, we find our lead should be 27 ft. long, 8 ft. of it being straight.

By reference to figures 2 and 3 it will be seen that