batch may be prepared while another is entering the mixer. This seems like a very simple requirement, yet the authors have often seen a single gang measure out the materials on the ground while the machine stood idle, and then lift them to a height of perhaps 3 or 4 feet, while the mixed concrete fell to the ground to be shoveled into barrows. With such an arrangement, hand-mixing is cheaper than machine-mixing.

Gravity machines, properly so-called, require no power, the materials being mixed by striking obstructions which throw them together in their descent through the machine. A gravity concrete mixer is illustrated in Gillmore's "Treatise on Limes, Hydraulic Cements and Mortars,"* first published in 1863. In this machine the concrete fell into successive hoppers opened and closed by hand-levers.

A well-known modern type of the gravity machine, shown in Fig. 87, may be increased in length from 4 to 10 feet by adding different sections. In falling through the slanting tube the materials are thrown by the deflectors on the sides and the curved back — the deflectors also acting as tables upon which the stones are coated with mortar—against several series of iron rods which mix them violently together. The inventor claims that by this violence the cement is pounded into the fractures and indentations of the sand and stone so as to increase

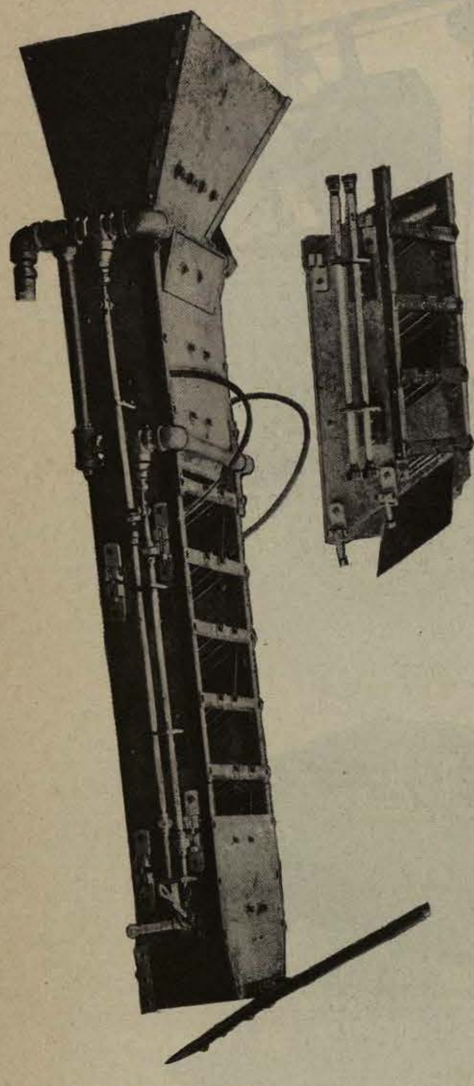

FIG. 87.—Gravity Mixers. (*See p.* 263.)

*Page 229.

the strength of the concrete produced. The materials generally are measured in layers on a platform above the machine and fed by shovels, but may be fed by a tipping box or by a derrick bucket. In the latter case the mixer becomes practically a batch machine.

Another gravity mixer is illustrated in Fig. 88. Four cone-shaped

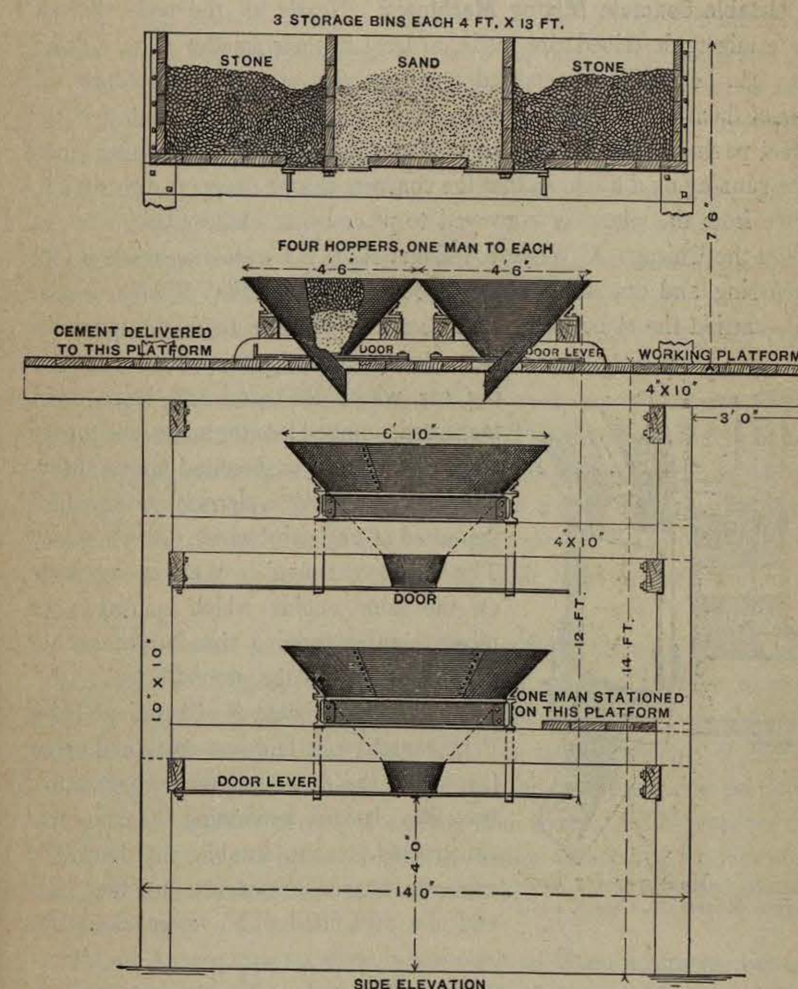

FIG. 88.—Gravity Mixer. (*See p.* 263.)

hoppers at the top of the machine receive the materials in layers, with the cement at the bottom and the coarsest material at the top. From these, on the opening of gates, the mixture falls into a single cone below, and thence at the will of an operator into a still lower cone, whence it drops into the car or other receptacle. The same type of mixer is used with a derrick so that the mixing progresses while the material is being swung to place. A series of cone-shaped buckets, telescoping each other when at rest, are connected with chains so that the concrete materials may be placed in the upper one and will fall when this is raised through an opening in the bottom to the next, and so on to the lowest bucket, from which it is dumped into the work by the operator at the place where it is needed.

Portable Concrete Mixing Machinery. Nearly all the types of concrete mixers described are made, at least in their smaller sizes, so that they can be readily transported from one part of a job to another. A few of them are adapted for such work as laying a thin foundation for street paving, while the heavier machines are sometimes arranged upon cars running on a track, so that the concrete can be dropped directly into place from the mixer, or conveyed to place by an endless belt.

On the Chicago & Western Indiana R. R.* a train was made up for preparing and depositing concrete for retaining walls. Three or four cars carried the stone, sand, and cement, and from these the materials were conveyed by wheelbarrows to the mixing car, where the sand and stone were measured, dumped into the mixer, and thence on to a belt conveyor mounted upon a swinging steel boom like a derrick boom, which deposited at any point within derrick swing. The train was hauled by the winding drum on the same engine which operated the mixer, a cable running ahead to an anchor or "dead-man" in the ground.

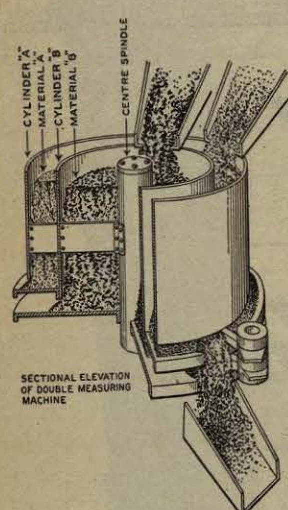

FIG. 89.—Measurer for Concrete Materials. (*See p.* 265.)

In building a dam at Chaudiere Falls, P. Q.,† tracks were laid just above and below the site of the dam and parallel to it, and a traveling platform containing the mixer was constructed so as to straddle the dam. The mixer discharged the concrete into the upper end of a tube fitted with a lower telescoping section, so that it could be deposited directly on any part of the dam.

Automatic Measurers for Concrete Materials. The accurate measuring of concrete materials by mechanical means has not been extensively developed. One difficulty, if methods of volumes are employed, lies in the inaccuracy of measuring cement by volume.

**Engineering News*, Feb. 28, 1901, p. 149.
†*Engineering News*, May 7, 1903, p. 403.

One patented device consists of several drums, one for each material placed directly under the bins containing the cement, sand and stone, and rotating upon the same horizontal shaft. The quantity of each material is regulated by the position of the gates in the bins and by the speed of rotation.

Another machine delivers the different materials through separate troughs containing Archimedean screws.

Another type of measuring machine, the working of which is illustrated in Fig. 89, consists of one or more bottomless storage cylinders, from under which the material flows out on to revolving discs or tables, and is peeled off by stationary adjustable knives which rest upon the discs and project into each material a distance determined by the quantity of each required.

A partially automatic measuring arrangement was employed on one section of the Boston Subway, in 1896. Each material fell into a closed chute arranged with gates at such distances apart as to enclose the required volume, whence it dropped into a hopper above the mixer.

Proportioning by Weight. Attention has been called on page 217 to the fact that not only cement, but also sand, stone, and gravel, can be more accurately proportioned by weighing than by volume measurement. When a large amount of concrete is to be mixed, it is possible to arrange apparatus for weighing each material in such a way that less labor will be required than for proportioning by volume. The first cost of the scales may often be more than counterbalanced by the accuracy in proportioning, which permits of leaner mixtures, while at the same time greater uniformity is assured.

In view of these facts, the authors predict that engineers will gradually recognize the advantage of proportioning by weight. In most cases excessive cost may prohibit the use of standard scales, but if the materials are accurately screened and subdivided, the relative weights of each on the same job will be so nearly constant that the weighing can be performed by a simple system of counterweights and levers. With properly constructed gates to the bins it might be possible to arrange for their automatic closing after the required weight of each material had been received in the hopper.

Measurements by weight are employed to excellent advantage by Warren Brothers Company at their various plants where the materials, which consist of stone, sand, and binding material, are prepared for their bituminous macadam pavement. Eight bins containing aggregates of different coarseness drop their materials through gates into a hopper which forms the platform of the scales and is located directly above the mixer. The scale-beam is compound, with as many arms as there are ingredients to be weighed, and each of the arms has a sliding weight and a stop so arranged that the sliding weight can be moved only to the point on the beam which will balance the required weight of one of the materials. When the sliding weights are all at zero and the hopper is empty, the scale balances. The weight on one of the arms is moved out by the laborer who operates the apparatus until it comes to the stop fixed at the point corresponding to the weight of the material to be used from a certain bin. The gate of this bin is opened, and the material allowed to run into the hopper until the scale balances. The weight on the next lever is then slid out, and the second material deposited in like manner upon the first. When all the materials are thus weighed, the entire mass is dropped into the mixer below.

Measuring Water. The water for each batch of concrete should be measured. The quantity of water used in different batches must be varied occasionally because of the conditions of the materials, but even in such cases the amount can be regulated best by measurement. A tank with a float connected with an indicator on the outside is easily constructed.

CONCRETE PLANTS

The design of the plant for handling the raw materials and the concrete usually has more to do with an economical production than the type of the mixing machine. The plant should be drawn or sketched on paper and accurate estimates made of its cost and the expense of operation, so as to determine whether the volume of concrete is sufficiently large to warrant its installation. The authors have occasionally seen expensive machinery, which could not be readily transported to another job, installed on a section of work where, because of the small total volume of concrete and on account of its distribution, hand-mixing was really more economical.

It is evident that the arrangement of any plant must be determined by local conditions, such as the contour of the ground, the distance from which the raw materials are transported, and the class of construction. A description of several plants, successful and economical in operation, may afford suggestions for other work. The illustrations are intended to show the arrangement of the gang and conveying machinery rather than the type of mixer.

Platform over Mixer. A common practice with mixers of various types, where the conformation of the ground permits, and where the quantity to be laid does not warrant the introduction of bins or machinery for handling the aggregate, is to locate the platform for measuring materials directly above the mixer. When ready they are shoveled through a hole in the planking into the machine. One gang of men can measure and spread the materials for a batch while another is shoveling it in. If the mixer is run as a batch machine, the materials may be measured directly into a hopper above it.

A satisfactory arrangement for a stationary batch mixer is illustrated in Fig. 90. The bin above the hopper is divided into two compartments for the sand and stone, and these are measured by feeding them to definite heights in the hopper, while the cement is dumped into the chute in front.

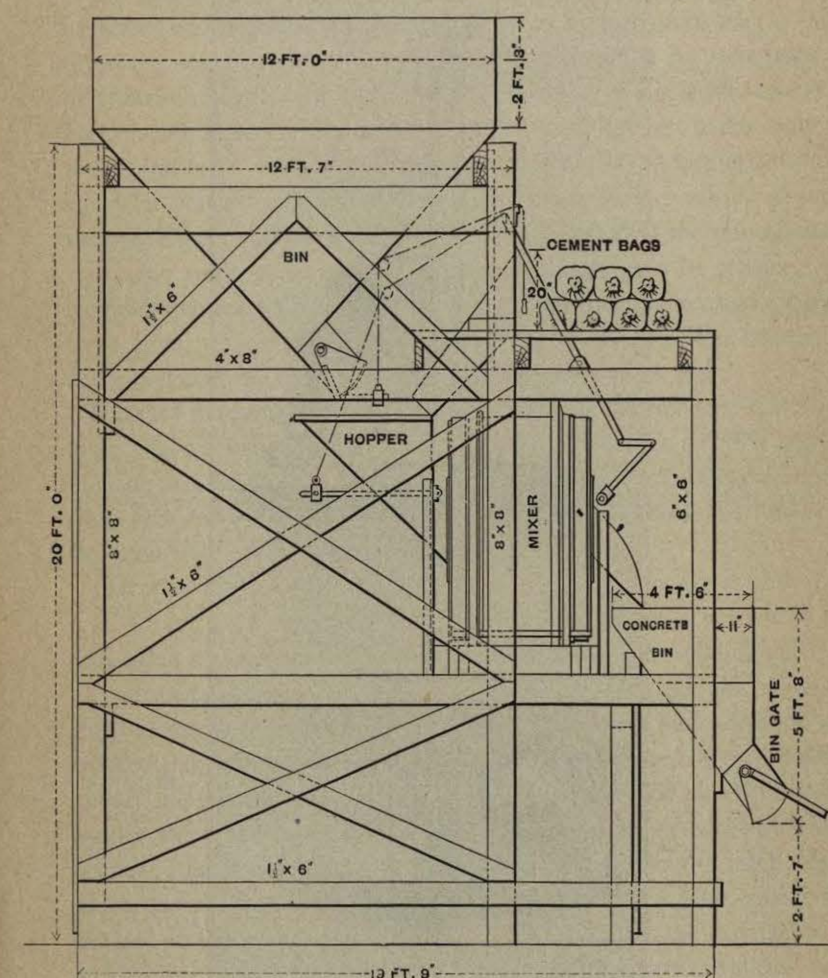

Fig. 90.—Stationary Mixing Plant with a one-yard Rotary Batch Mixer. (*See p.* 267.)

Building Construction. The concrete for building construction may be elevated in buckets running in a light timber frame or on steel guides as shown in Fig. 91.

A Central Plant. The establishment of a central plant from which the mixed concrete may be hauled to various points as required may be economical in some cities or large towns. This plan has been adopted in St. Louis, Mo.,* for concrete, and is employed in many places for tar and asphalt

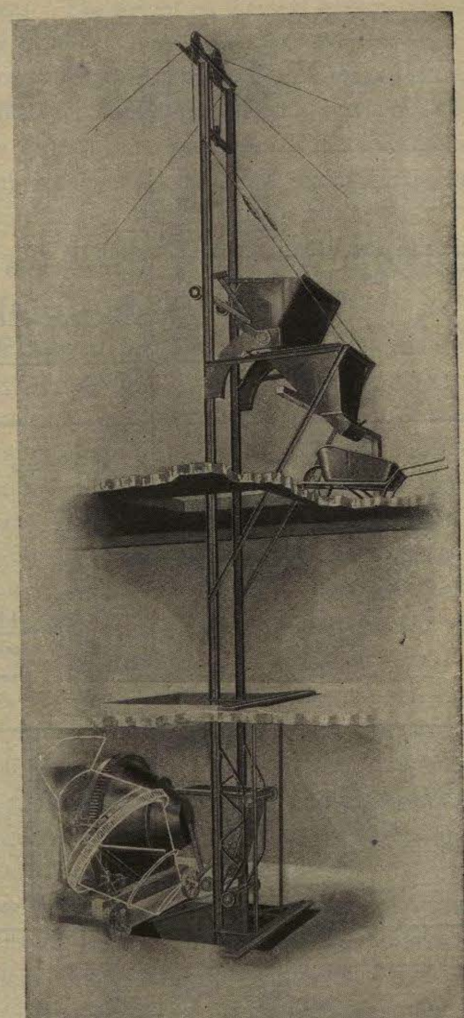

Fig. 91.—Automatic Dumping Concrete Elevator. *(See p. 267.)*

paving. The plant may be located at a gravel bank or stone crusher, or near a railroad siding, permanent machinery provided which will mix the concrete at a much lower cost than could be done by hand-mixing, and the concrete hauled in carts to the work at but slightly higher cost than the hauling of the dry materials. Most Portland cement con-

*Engineering News, March 10, 1904, p. 231.

crete will not be injured (see page 157) if laid within an hour or two after mixing.

Charlestown Bridge Pier. An economical handling of materials and concrete, where the only machinery was the concrete mixer, is shown in Fig. 92, which illustrates the building of the foundation for the draw pier of the Charlestown Bridge, Boston.* The gravel and sand were brought on scows and deposited so near to the mixer as to require only a short throw or wheelbarrow haul, and were then measured by shovelfuls, as described on page 259. Eight wheelbarrow men, in single file, conveyed the concrete from the paddle mixer, which is shown just to the right of the central mast, along the circular run, then on to the turn-table to the chute for depositing it under water. The entire gang consisted of some thirty-five men, and when working steadily they laid at the rate of about 170 cubic yards of concrete in ten hours, which may be considered a maximum output for a machine of this character, the more usual quantity being from 75 to 100 cubic yards per day of ten hours. The method of depositing concrete from the chute is described on page 303.

Harvard Stadium.† At the Harvard Stadium the builders, the Aberthaw Construction Company, erected a movable tower on each side of the site, and the buckets of concrete and the seat slabs‡ were then taken from cars and conveyed by the cable suspended between the towers to the point where they were needed.

Chicopee River Dam. In mixing concrete for a dam across the Chicopee River in Massachusetts, the contractors utilized a portion of the excavation by locating their mixer against a bank and building out over it a covered platform containing the hopper from which the materials could be dropped directly into the mixer. Stone from the excavation was crushed and elevated to storage bins, whence it was hauled by carts holding exactly the quantity required for a batch, and dumped directly into the hopper above the mixer. The sand was measured and wheeled to the hopper in an iron vehicle consisting of a bucket set on two large wheels which dumped into the hopper by rotating on its axis. The cement was emptied on top of the sand. One batch was mixing in the machine while another was being emptied into the hopper, and thus twenty batches could be handled per hour. The concrete was dumped from the mixer into carts which conveyed it to the dam.

Cambridge Electric Light Station. A portable mixing plant em-

*Sixth Annual Report Boston Transit Commission, 1900.
†See Frontispiece.
‡See chapter xxiv.

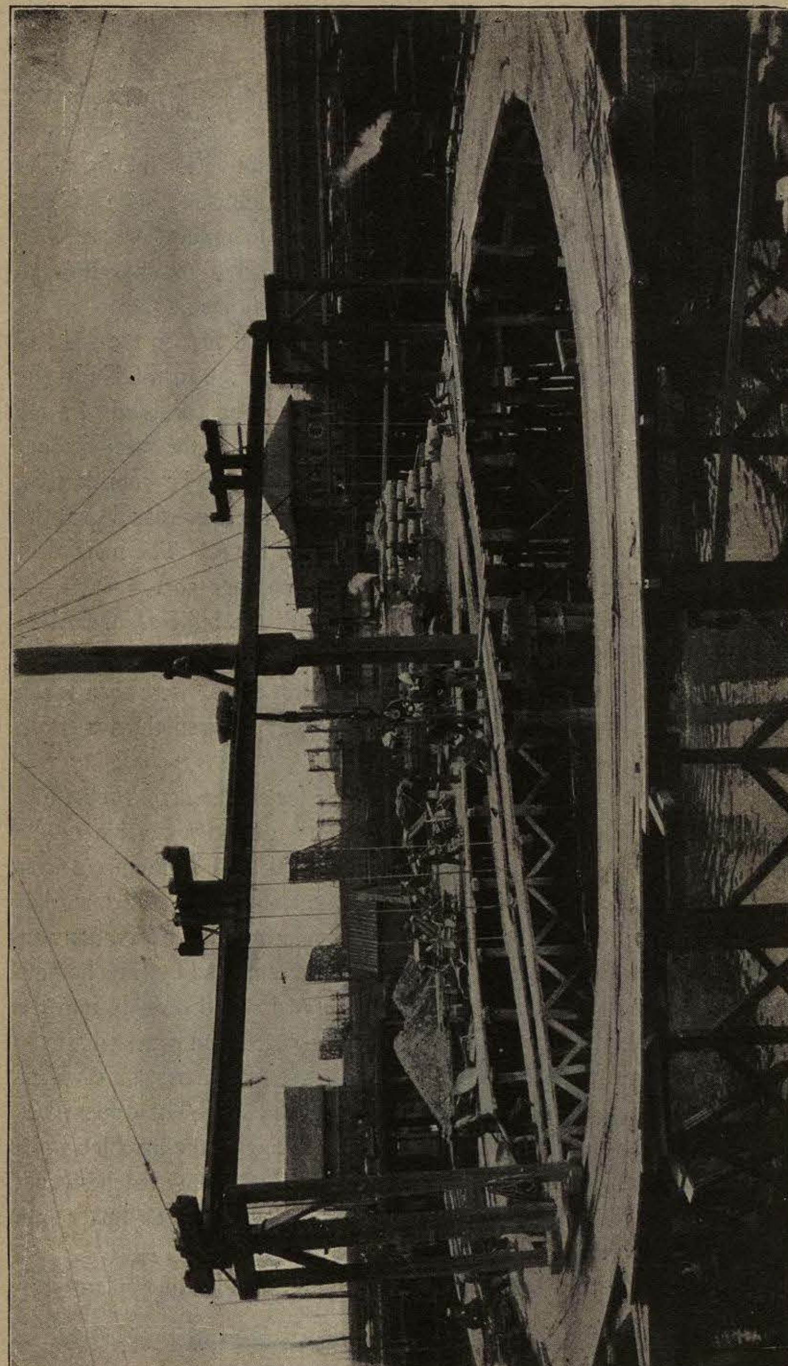

FIG. 92.—Depositing Concrete of Draw Foundation Pier, Charlestown Bridge. (See p. 269.)

ployed on the Cambridge (Mass.) Electric Light Station is shown in Fig. 93. The special feature of the arrangement is the framework containing the mixer. This may be taken up by the derrick, which also supplies it with raw materials, and moved in a few minutes to any other position within derrick swing, so that the concrete can be dropped from the mixer close to or directly upon the place where it is required.

East Boston Tunnel. For measuring materials brought in cars to the work, the contractors for one of the entrance sections of the East

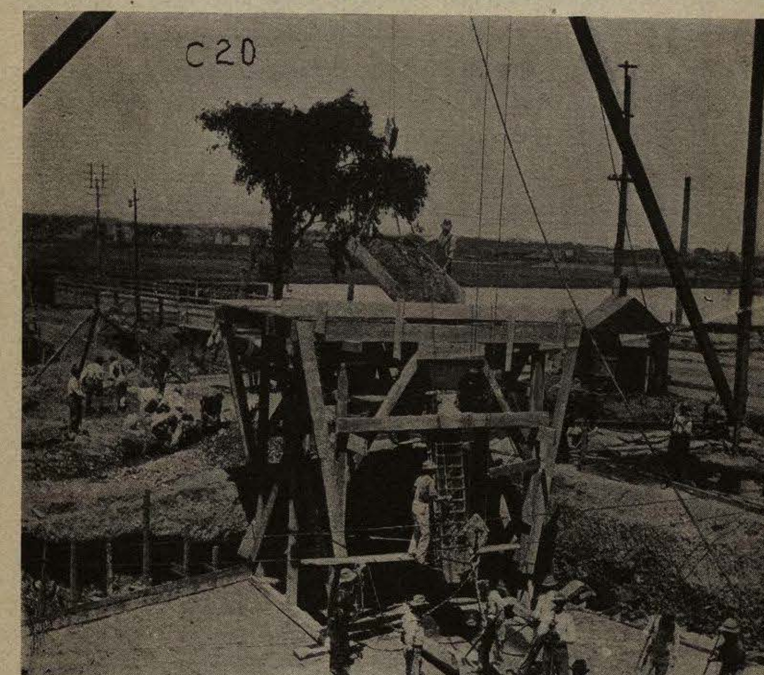

FIG. 93.—Portable Mixing Plant. (See p. 271.)

Boston Tunnel employed a derrick bucket. The stone was first filled in to a height determined by a gage, then the sand was shoveled on top of it and struck off with a different gage, and finally the required number of bags of cement emptied on top of the sand. The bucket was taken by a derrick and dumped into a duplex mixer.

Cambridge Bridge Piers. When the quantity of concrete to be laid warrants the installation of the necessary machinery, economy requires that the stone and sand shall not be handled at all by laborers. If the stone is crushed on the spot, it may be raised to bins above the mixer

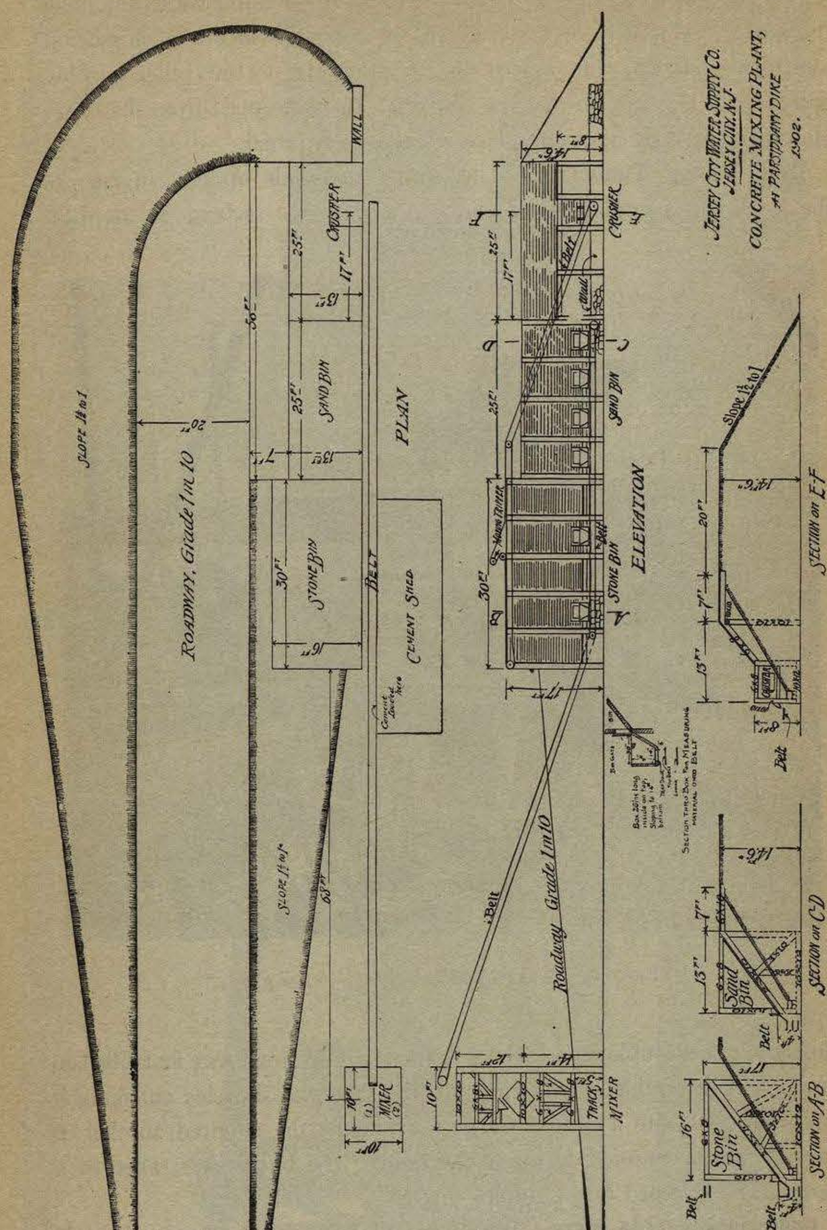

FIG. 94.—Mixing Plant Employing Belt Conveyor. (See p. 273.)

by bucket elevators or belt conveyors, while a similar plan for elevating the material may sometimes be advantageously followed where gravel is used. In building the substructure of the Cambridge Bridge, Boston, Mass.,* the concrete plant was located on a pier resting on piles. The gravel for the concrete was dredged from the harbor and dumped from scows into the water close to the pier. An "orange peel" bucket, operated from a dredging machine on a scow, lifted the gravel, and dropped it into a hopper whence it ran by gravity upon the combination inclined screen described on page 240, which separated the sand, pebbles, and the coarse waste material. Bucket elevators raised the sand and pebbles to bins above the mixer, and from the bins, which were V-shaped, the materials fell by gravity into the measuring hoppers. These were arranged in two sets, an essential requirement for maximum output, so that one batch could be measured while another was being dropped into the mixer. The barrels of cement were brought from the cement shed by a horizontal endless chain, opened on the ground under the mixer, and then three barrels, enough for one batch, were raised at one time by a bucket elevator to one of the hoppers over the mixer.

Williamsburg Bridge Pier. A method of measuring the materials in cars was adopted in building one of the anchorages of the East River Bridge, New York. The cement and sand were stored in bins, and fell by gravity into cars whose capacities were equal, respectively, to the volume of stone and sand required for a batch. Between the tracks upon which these cars ran were two holes in the ground into each of which could be lowered a box of sufficient size to hold one batch of the broken stone, sand, and cement. By tipping the measuring car the broken stone was dumped into the box, the sand fell from another car through a trap door, and the cement was dumped in from the bags. After filling, the box was raised by a derrick and dumped into the mixer.

Parsippany Dike. An endless rubber belt furnishes an excellent means for handling concrete raw materials in a stationary plant. The width of the belt should be not less than 18 inches and the slope no greater than about 22°, which corresponds to 2½ feet horizontal to one foot vertical. Idlers for giving the proper V-shape to the belt were placed at proper intervals.

The plan in Fig. 94, page 272, shows the design by Mr. William B. Fuller of a plant used at the Parsippany Dike of the Jersey City Water Supply Co., N. J. The sand was brought to the bins and the stone to

*For full description see article by Sanford E. Thompson in *Engineering News*, Oct. 17, 1901, p. 282.

the crusher in wagons. A belt conveyor delivered the crushed stone to the bins. At the outlet of each bin a measuring hopper (shown in a detail section, in Fig. 94), containing about 8 cubic feet, received the sand or stone from the bin, and at the ring of a bell the proper quantity of each material for one batch of concrete was dropped upon the conveying belt. The cement was emptied from bags on top of the sand and stone as they were carried past the cement shed. The bin over the mixer had two hoppers. As soon as a batch was delivered to hopper No. 1, the bell was rung again and another batch started into hopper No 2, and while this was filling No. 1 batch was dumped into the mixer.

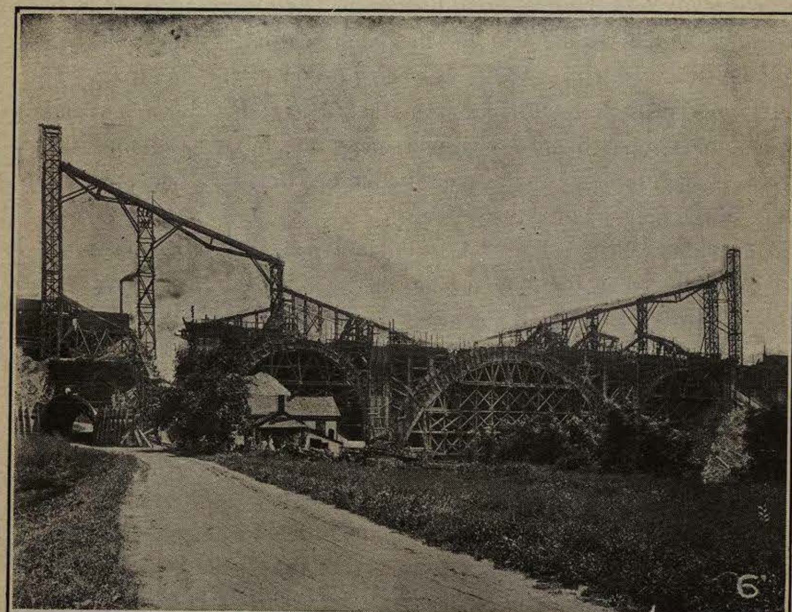

Fig. 95. Mixing plant at Painesville Bridge. (*See p.* 275.)

Blackwell's Island Bridge Piers. At a plant of somewhat similar design built for the piers of the Blackwell's Island Bridge, N. Y., the sand and stone were measured in cars running on a track below the bins. so that they could be moved from one gate to another and discharged at any point through trap doors on to the belt between the rails. The stone was carried up from the crusher by another belt to the top of the bins, where it fell off the belt on to an inclined screen, and rolled into a bin, while the dust, passing through, dropped on to another short belt which carried it to another bin to be used as sand.

Jerome Park Reservoir.* During the construction of the reservoir at Jerome Park, New York City, in 1906, the concreting of the large bottom and slope areas was systematically arranged by using a number of medium sized rotary batch mixers, each with a separate gang with wheelbarrows. The mixers were moved from time to time.

Chalmette Docks at New Orleans.† The concrete for the slip walls of the Chalmette Docks, New Orleans, was handled and mixed by a portable plant on standard gage tracks, consisting of a flat car with a 2-cubic yard hopper at each end which supplied sand and gravel to inclined belt conveyors. These discharged into a 3-cubic yard hopper with an undercut gate placed above a ¾-cubic yard rotary mixer at the center of the car. Cement was supplied the mixer by hand from a storage platform on the side of the car, and water, from a pipe laid along the wall with hose connection at convenient intervals.

Painesville Bridge. A unique method of handling concrete at the Painesville Bridge of the L. S. & M. S. R. R., completed in 1909, is illustrated in Fig. 95. Concrete was elevated in towers at each end of the bridge and flowed in movable spouts by gravity to place.

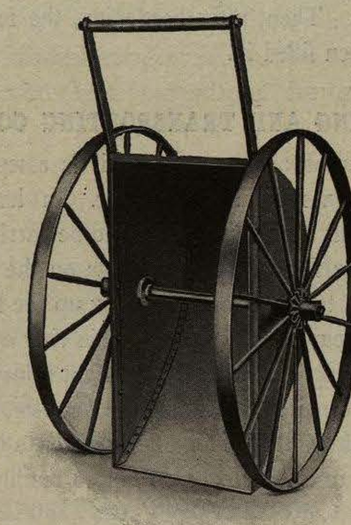

Fig. 96.—Two-wheeled Concrete Car. (*See p.* 277.)

* *Engineering News*, Sept. 21, 1905, p. 298.
† *Engineering Record*, July 29, 1906, p. 88.