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A SURVEY OF CONCRETE
HANDLING EQUIPMENT

Thesis for the Degree of B. S.
MICHIGAN STATE COLLEGE
Robert V. McClure
1948

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A Survey of Concrete Handling Equipment

A Thesis Submitted to
The Faculty of
MICHIGAN STATE COLLEGE
of
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By

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Candidate for the Degree of
Bachelor of Science

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INTRODUCTION

The equipment referred to in this thesis is that equipment used for the handling of portland cement concrete, a non-bituminous concrete, which should not be confused with any of the bituminous forms. Portland cement, the binding material in the concrete, was first produced in 1824. Naturally, methods of handling concrete at that time were rather crude and laborious. Since then, however, great advances have been made in developing equipment with which to mix, transport, and process the concrete more easily.

Concrete was first mixed entirely by hand by means of a hoe and mixing trough. Today this practice is used only for the smallest amount of concrete work and in general is never considered by anyone having any large volume of work to do. Concrete mixers, both hand and power driven, have proved to be much more economical and to produce a better concrete.

In transporting concrete, some of the very first methods are still being used today even on the larger construction jobs. Improvements have been made and different methods developed, but some of the first practices, because of their simplicity and ease of operation, have never been outmoded. The biggest problem in transporting concrete is the possibility of segregation once the concrete has been thoroughly mixed. However, this has been overcome by some of the more recent transporting methods. Mixing concrete while it is in transit, remixing the concrete after it has been

hauled a comparatively long distance, and using air entrained cement which prevents segregation are some of the more common present day practices.

Processing concrete refers to the methods used and the work required to put the concrete in its final form or permanent position. Again, the first methods employed were hand operations of finishing, puddling, etc. These first practices are still in use today on smaller construction jobs, but have been replaced by more economical and labor saving mechanized methods on larger jobs.

Before investing in higher priced concrete handling equipment, the volume of work at hand must first justify such a purchase. Only with a large quantity of work in which a piece of equipment can be kept in almost continual operation, is an outright purchase warranted by and profitable for the owner. Otherwise, the cost of ownership will greatly overbalance any benefits derived. Contractors engaged in concrete construction work should first survey their own needs, and then purchase the equipment that will most economically satisfy these conditions.

MIXERS

Concrete mixers are usually divided into three classes-- batch mixers, continuous mixers, and gravity mixers. In batch mixers the ingredients of the concrete in proper amounts are placed in the machine, mixed, and discharged before another batch is placed in the mixer. In continuous mixing, the materials are allowed to enter the machine and the concrete to discharge continuously. Gravity mixers consist of specially constructed hoppers, troughs, or tubes so arranged that the ingredients flowing through them under the influence of gravity are mixed together into concrete.

Batch Mixers. Batch mixers are commonly of two types-- one in which the drum is tilted in order to discharge the mixture, or one in which the drum is not tilted, but has the concrete raised in the mixer by mixing paddles and dropped on the inner end of a discharge chute which conveys it to wheelbarrows or other means of placing. Mixers of this class are usually rated according to their capacities of cubic feet per batch, and whether the means of discharging is a side or end dump. The letter S denotes side dump common to construction mixers and the letter E denotes end dump common to paving machines. Capacities of mixers used in construction work range from $3\frac{1}{2}$ cubic feet to 3 or 4 cubic yards or more. These machines as all mixers are powered by gasoline, electric, or diesel engines; gasoline engines are most commonly used.

The following table shows a comparison of some of the more commonly used batch mixers.

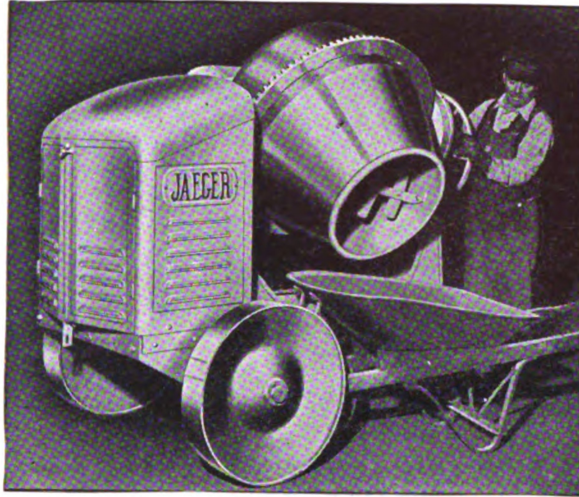
<u>Capacity</u>	<u>Type</u>	<u>H.P.</u>	<u>Approx. Weight</u>	<u>Output Per Day</u>
3½S	Tilter	2½	1325#	35 Yds.
3½S	Drum	3.7	1325#	50 "
6S	"	8	3200#	85 "
11S	"	16	5100#	155 "
16S	"	30	7350#	225 "
28S	"	30	10500#	400 "
56S	"	60	19800#	800 "

Continuous Mixers. Continuous mixers are more widely used in concrete products plants. Their mixing mechanism is completely different from other types of mixers, for it consists of a substantial square shaft carrying numerous paddles. By means of these paddles, revolving 70 times a minute, the material is mixed, cut, turned, and returned 1800-2500 times a minute. Water is added continuously after the sand, gravel, and cement are thoroughly mixed to give a continuous flow of concrete.

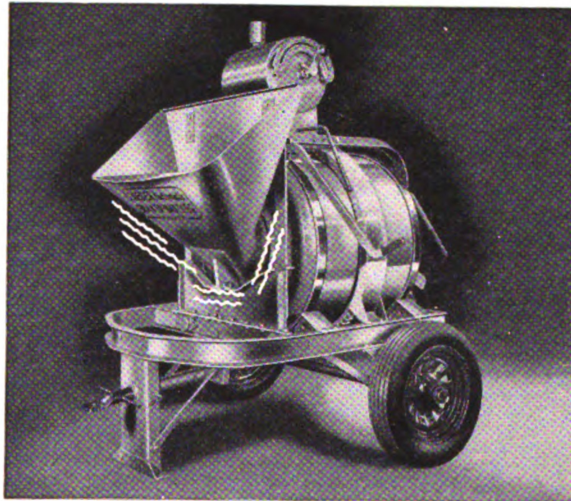
Gravity Mixers. The most common form of gravity mixers consists of two or four small hoppers (depending upon the size of the mixer) set upon a frame support. Below these top hoppers three large hoppers are set, one below another. To operate the mixer after the top hoppers have been charged the gates of these are opened, and materials allowed to pass into the hopper below. There it is caught and held until

this hopper is full, after which the gates are opened, and the material allowed to flow into the next lower hopper and so on until the concrete is received in the bottom hopper and is ready for use.

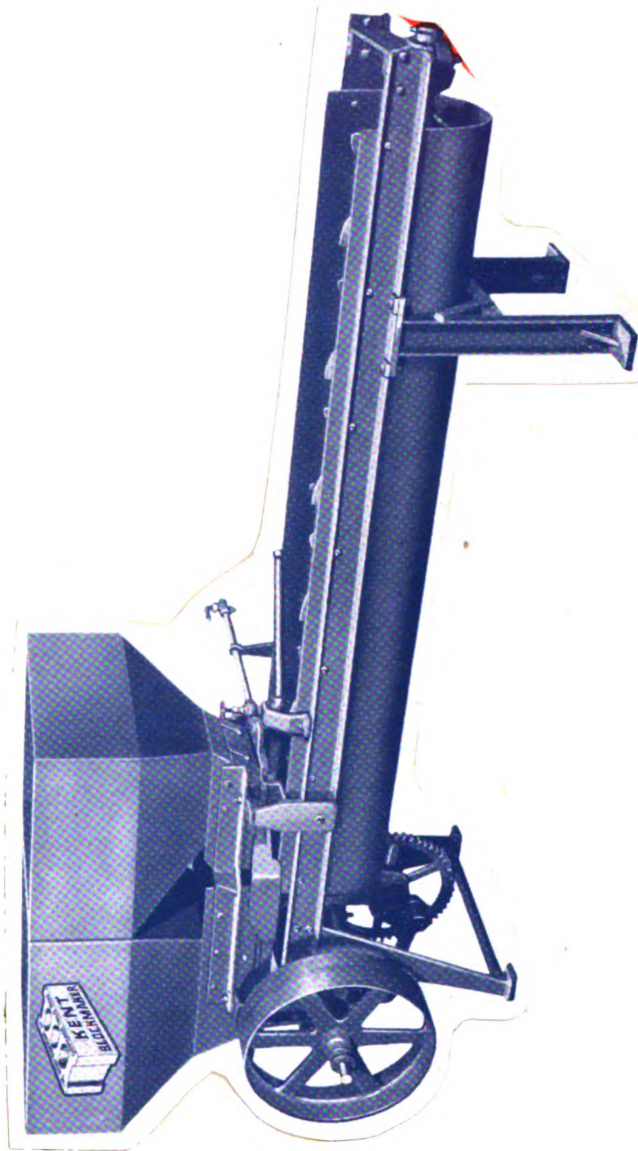
Plaster-Mortar Mixers. The plaster-mortar mixer is a special type of batch mixer. The mixing compartment is designed to have a criss-cross mixing action so as to cut through the materials, and not merely tumble them around as in the ordinary batch mixers. A comparatively small machine, the plaster-mortar mixer generally handles a one-bag batch yielding up to 8 cubic feet.



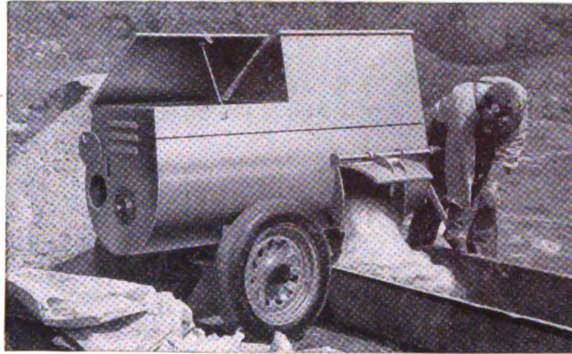
A 3 $\frac{1}{2}$ S Tilter Type Batch Mixer.



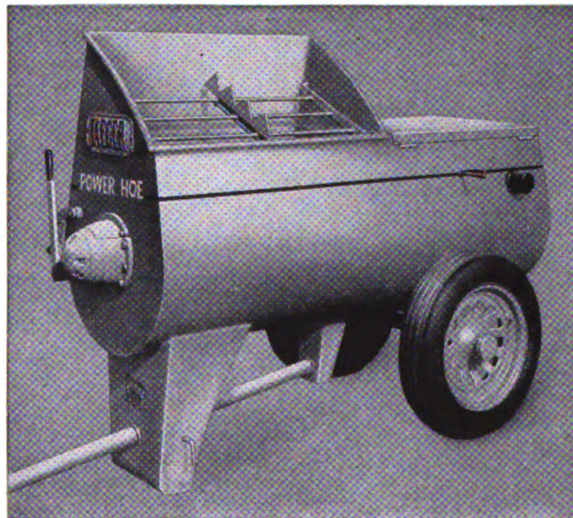
A 3 $\frac{1}{2}$ S Drum Type Batch Mixer.



A Continuous Mixer with a Capacity of 8 Cubic Yards per Hour.



A Mixer Dumping Mortar.



A Plaster-Mortar Mixer.

PAVERS

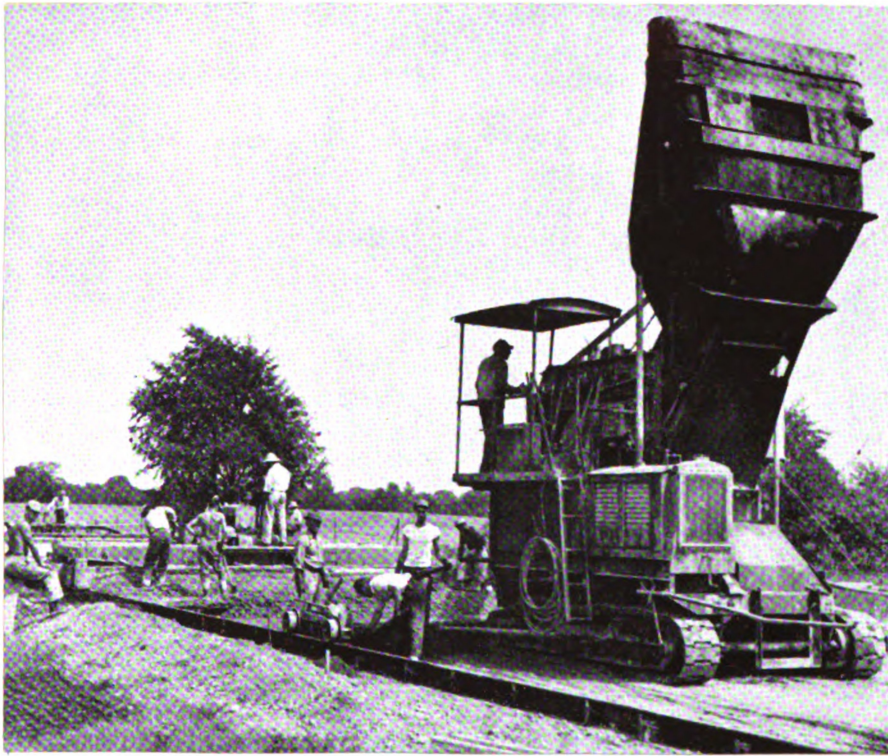
Pavers are comparatively large batch type mixers designed exclusively for mixing and placing concrete on the subgrade of a highway or airport. Various sizes of mixers have been used for paving, but a mixer of one cubic yard per batch capacity has been found by experience to be the most efficient size under average conditions. Pavers are self propelled machines, and are operated on the subgrade. They have the following component parts:

1. Skip--Batches of sand, gravel, and cement from trucks are received by the skip and discharged into the mixing drum.
2. Mixing Drum--Here the concrete is mixed.
3. Water Measuring Tank--This measures accurately the water per batch and feeds it into the mixing drum.
4. Boom and Bucket--Concrete from the drum is discharged into the bucket which moves along a boom that may be swung over the width of the pavement between the forms.
5. Source of Power--A gasoline, diesel, or electric motor is used to furnish power for movement and operation of the machine.

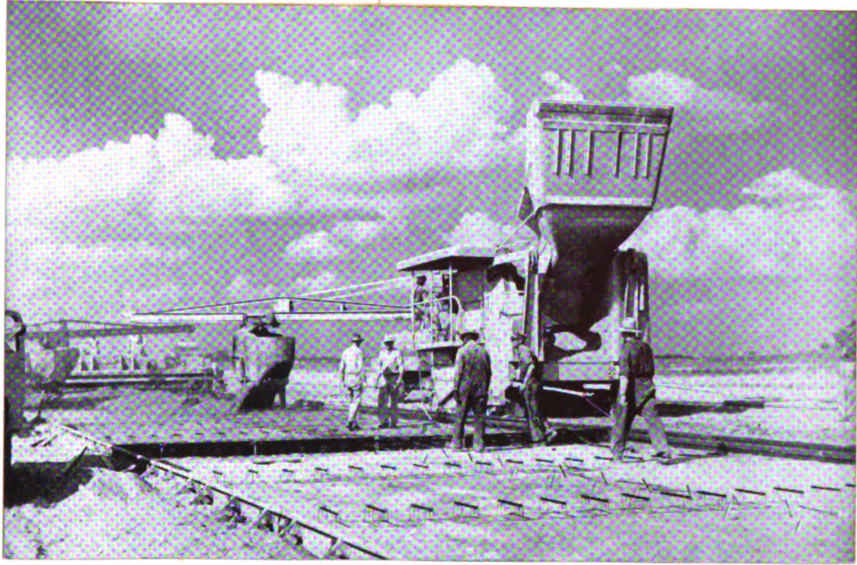
Most mixers are equipped with automatic timing devices allowing the concrete 60 seconds of mixing time--a time which has been adopted almost universally. Dual drum mixers,

in which concrete is partially mixed in one drum and transferred to a second drum for completion of the mixing, have a limited use, but do possess the advantage of having a larger output.

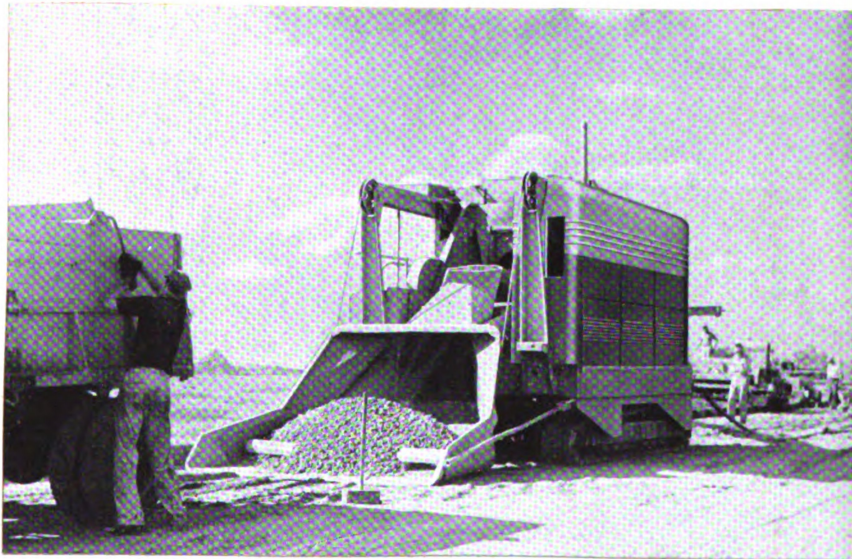
A special type of paver with a 7 to 10 cubic foot batch capacity is frequently used for mixing concrete for widening pavements. These machines, in general, are not equipped with the boom-and-bucket type of delivery.



Older Type Paver Operating on Subgrade.



A Paver Placing Concrete on the Subgrade.



Loading the Skip on a Paver.

TRANSIT MIX TRUCKS

Ready mix trucks or transit mix trucks, as we know them, are a comparatively recent means of transporting concrete. They have the distinct advantage over any other type of transporting device in that they continually mix the concrete as it is being transported. This completely removes the ever present problem of segregation in the handling of concrete.

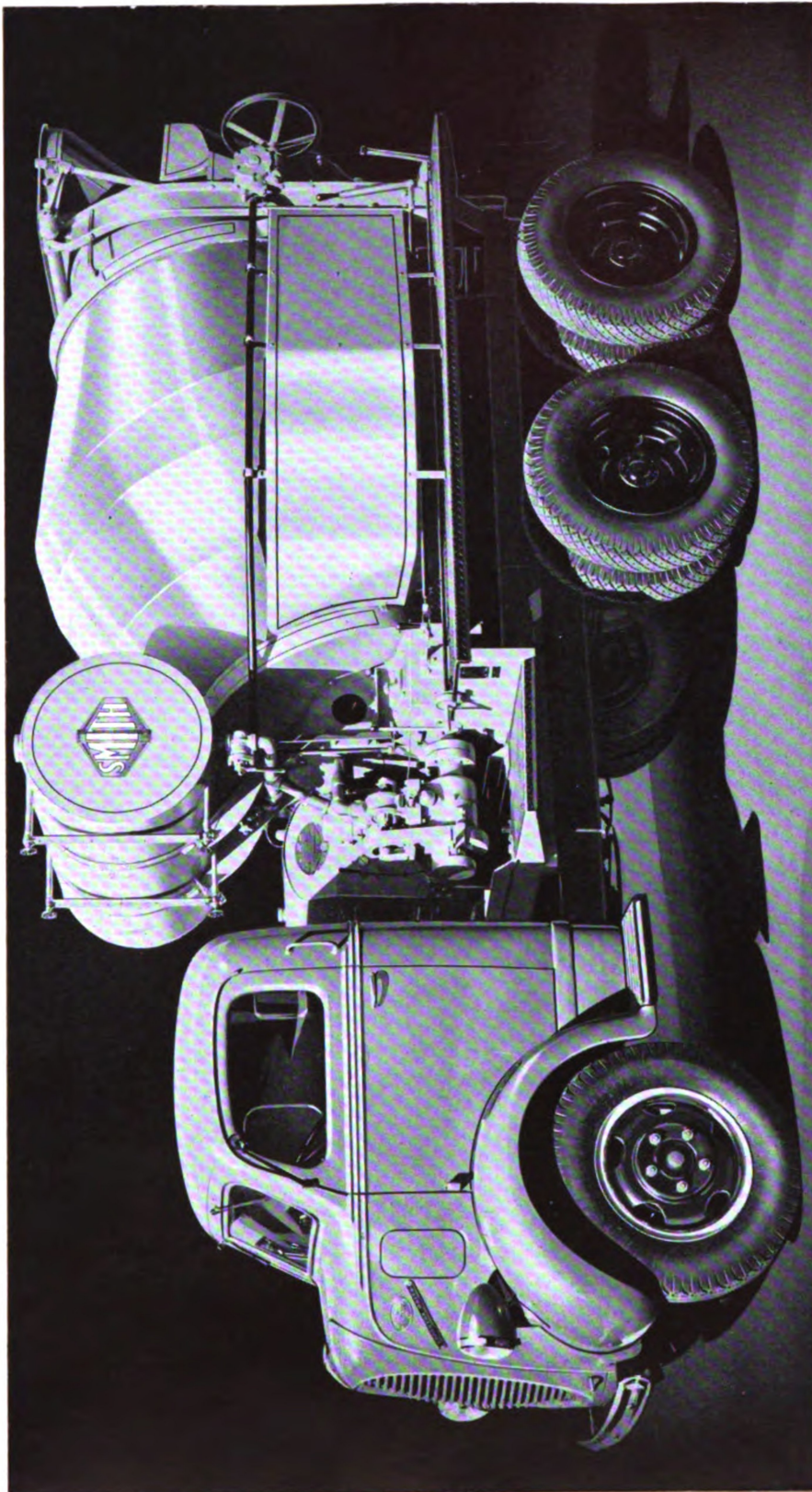
Transit mixers are loaded by either of two methods--top loading or end loading. Top loading has the advantages of being a faster method, of giving a better distribution of materials, and of being the only means by which a wet mix can be placed in the drum. Transit mixers may be used as either mixers or agitators. As a mixer, the sand, gravel, and cement are loaded dry, and the water is added en route to the job. As an agitator, the concrete is loaded already mixed and is merely agitated on the way to the job. Obviously, the agitator method should be limited to short hauls only. Some transit mixers have a feature known as a sealed drum for mixing. This is much better than any other type drum, because it holds the heat in winter, protects the concrete from bad weather, and prevents the drying of materials on a long haul. The drum generally has two or more operating speeds for long or short hauls, and a reverse gear for discharging the concrete. Power for operating the mixer is furnished by a 4 or 6 cylinder gasoline engine depending

upon the capacity of the drum. These engines are entirely independent of the motors of the trucks themselves. There is a type of transit mixer, however, that operates directly off the driveshaft of the truck. This is a tilting tub type mixer with a small capacity of less than 2 cubic yards.

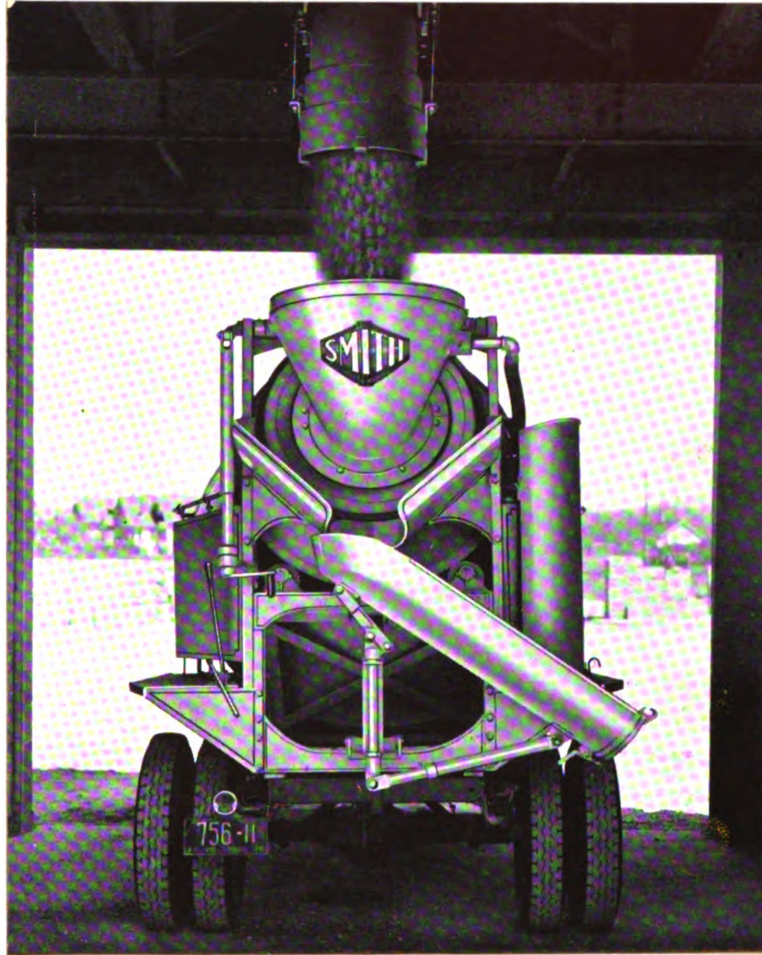
Some desirable features on the latest models of transit mixers are (1) high discharge for easier placing, (2) controlled discharge for pouring the concrete at any speed desired, (3) visible mixing to allow the contractor to inspect the mix before pouring, (4) large feed chute for easier spotting under the bin gate, (5) steep distributing chute for drier mixes, and (6) flushing tank filled with water for cleaning out the drum.

The following are some ratings and specifications for transit mixers:

<u>Type Mixer</u>	<u>No.2</u>	<u>No.3</u>	<u>No.3½</u>	<u>No.4</u>	<u>No.5</u>
Capacity as mixer-cu. yds.	2	3	3½	4	5
Capacity as agitator	2½	4	4½	5¼	6¼
Average weight-lbs.	4700	5300	6000	6700	8300
Drum speed-R.P.M.	4-10	4-10	4-10	4-10	4-10
Cylinder engine	4	4	6	6	6
Length distributing chute-ft.	8	8½	9	9	9



A Transit Mix Truck with a 4 Cubic Yard Capacity.



Charging the Transit Mixer.



Pouring Foundations with Transit Mixer.



Tilting Tub Type Transit Mixer.



A Transit Mixer Pouring Concrete on the Subgrade.

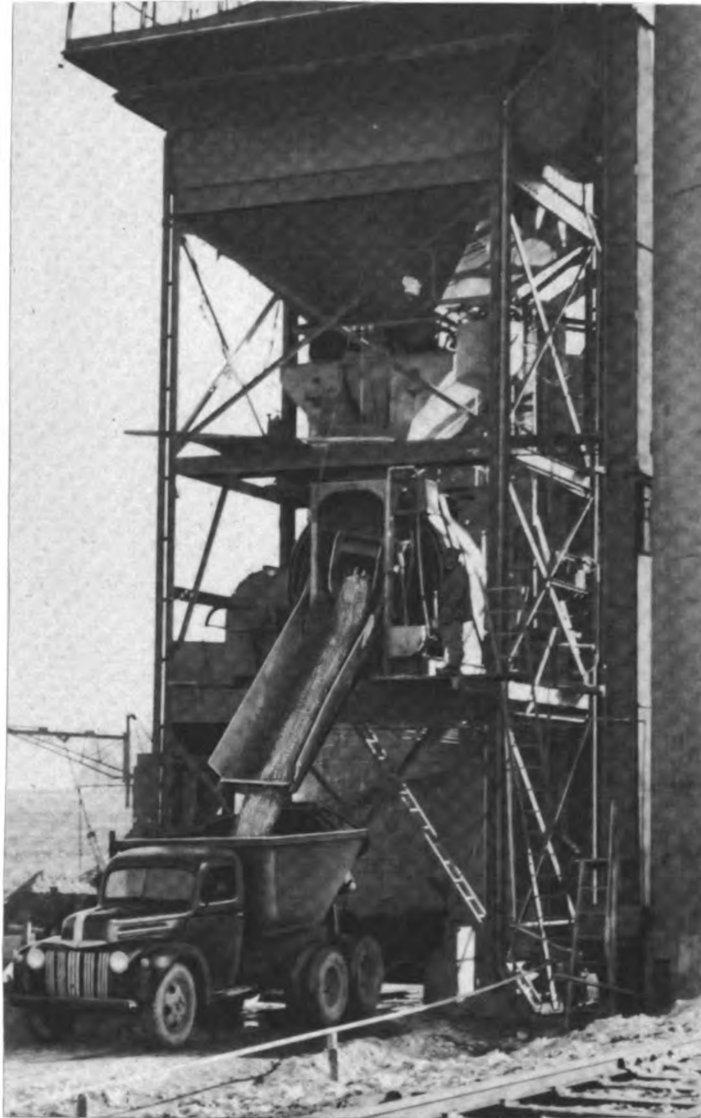
CONCRETE DUMP TRUCKS

With the development of air entrained concrete, modified forms of dump trucks are being used more and more for the hauling of concrete. It is now possible to use these non-agitating dump type bodies for transporting concrete, since the entrained air in the concrete practically eliminates the problem of segregation which would otherwise occur. Concrete has been hauled by this method on some construction jobs for distances up to 15 miles with no evidence of any harm having been done to the concrete. This method has also proven to be an enormous saving to the contractor. It allows him to set up at any convenient location a central batching plant which will furnish already mixed concrete for the duration of the project but will not have to be moved. By the use of dump trucks, larger volumes of concrete can be hauled at a greater rate of speed.

The concrete dump truck has one distinct advantage over the transit mix truck. The dump truck can be very easily loaded from the batching plant because of its open top as compared to the hatch of the transit mixer which must be opened and closed manually. The dump body must necessarily be watertight for its hauling of ready mixed concrete. The capacities of different trucks range from 2 to 4 cubic yards.

For discharging the concrete, most dump bodies can be tipped to an angle of 70 degrees while some tip as high as 90 degrees. Most bodies are designed for a fast discharge

which is less than 1 minute and usually about 30 seconds. However, most trucks are equipped with a clam shell type of gate which allows the discharge to be controlled to any speed desired. The maximum opening for discharging is an area of 18x22 square inches. A folding type chute for placing the concrete is attached to the rear of the truck. This chute is 6 inches wide and usually about 6 feet in length and may be rotated a full 180 degrees from one side to the other. An extension of equal length also is available.



Loading a Truck at a Batching Plant.



"Dumpercrete" Truck Pouring Concrete.



Modified Dump Truck Discharging Concrete.

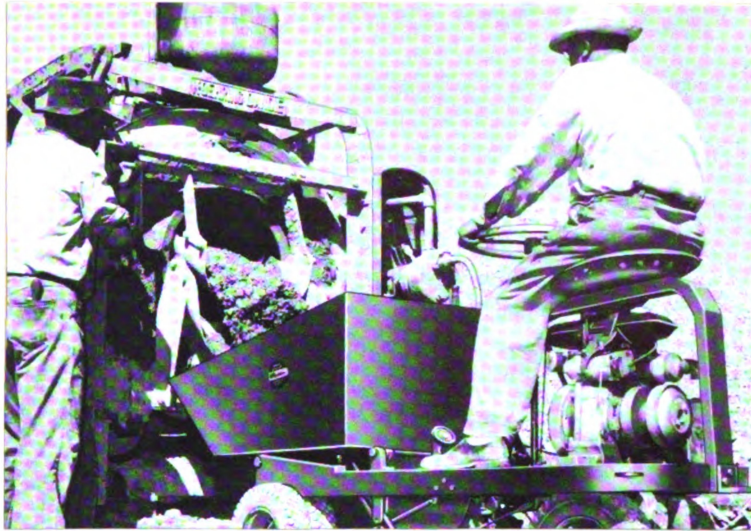
WHEELBARROWS

One of the first methods of transporting concrete was by wheelbarrow. Even though the use of wheelbarrows today is rather limited in larger construction work because of the more mechanized and efficient concrete hauling devices taking their places, they are still used to a great extent on small construction jobs. Wheelbarrows have a rated capacity of 2 to 3 cubic feet for hauling concrete. The limiting distance for economical haul is about 150 feet although they have been used successfully over distances up to 300 feet. A comparatively recent adaptation from the wheelbarrow is a form of push cart commonly known as a "buggy". Its advantage is the having of two wheels (one either side) allowing for a lower center of gravity and providing for a more stable load.

Replacing the wheelbarrow on the larger construction jobs are some self-propelled machines going under such trade names as "Power Buggy" and "Prime Mover". Rated capacities of these powered vehicles range from 1000 to 2000 pounds or 6 to 12 cubic feet of concrete. They are powered by a 3 to 6 H.P. gasoline engine which enables the machine to climb a 20% to 25% slope without straining. Besides being able to do about 5 times the work a wheelbarrow can do, these powered machines tire their operators less. The machines range from 400 to 750 pounds in weight, and operate under speeds varying from 2 to 15 miles per hour.



Pouring Concrete with a Buggy.



A "Power Buggy" Getting a Load.



A "Prime-Mover" Dumping a Load.

CONCRETE BUCKETS

There are three main types of concrete buckets used for the handling and placing of concrete on the job. Two of these types, the double clam gate bucket and the roller gate bucket, are used on the average construction project for placing concrete into forms; while the third type, the tremie bucket, is used exclusively for placing concrete under water. All three buckets rely on either a crane or cable for their mobilization.

Double Clam Gate Bucket. The double clam gate bucket is used in general for handling concrete of normal consistency on general construction work. Its narrow discharge gate makes it particularly adaptable to narrow form work, and the operator, straddling the forms, can work the discharge gate lever from this position. Having a comparatively small capacity, standard sizes of buckets are usually $\frac{1}{2}$, $\frac{3}{4}$, and 1 cubic yard. Some comparative specifications are as follows:

Capacity--cu. yds.	$\frac{1}{2}$	$\frac{3}{4}$	1
Weight--lbs.	630	692	875
Outside Diameter--in.	41 $\frac{1}{2}$	41 $\frac{1}{2}$	49 $\frac{1}{2}$
Height--in.	46	52	59
Discharge Area--sq. ft.	1.78	1.78	2.00

Roller Gate Bucket. The discharge gate of a roller gate bucket consists of a flexible rubber pad supported by sealed roller bearings. This eliminates the friction in the gate

mechanism and also the friction between the gate and the concrete. This type of bucket is available in various sizes up to 8 cubic yards in capacity and permits manual control of the discharge. More in particular there are two different designs of the roller gate bucket--one for low slump and one for normal slump concrete. The roller gate for low slump concrete has a diagonal discharge gate designed to increase the leverage for easier gate operation. The roller gate for discharging normal slump concrete is horizontal making it possible to have a steep slope in the hopper of the bucket and a large opening in the bottom. Some ratings and specifications for low slump roller gate concrete buckets are as follows:

Capacity	1	1½	2	3	4	5	6	8
cu.yds.								
Weight	1170	1675	1850	3700	4150	5200	6000	8000
pounds								
Out.Diam.	49	60	60	73	73	78	86	92
inches								
Height	69	79	82	93	108	113	112	124
inches								
Disc.Area	2.61	4.03	4.03	5.30	5.30	6.20	6.20	7.70
sq.ft.								

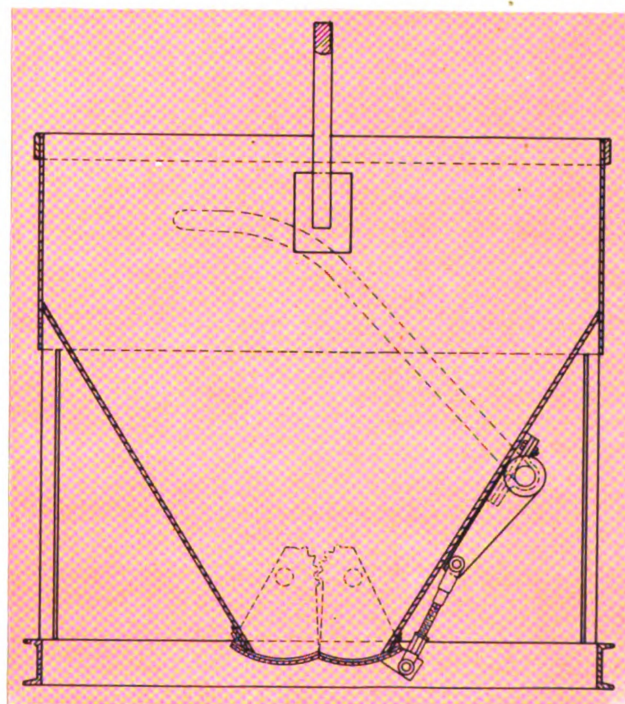
Tremie Bucket. The tremie bucket is a type of concrete bucket designed for the placing of concrete under water. The bucket, when filled and covered with a canvas top which protects the concrete from the swirling water above, is lowered into the water to the desired position. The concrete is discharged automatically merely by setting the loaded bucket down and slacking off on the chains. The horizontal double doors open to a vertical position leaving the entire

bottom open for discharging the concrete. The two discharge doors and the outside shroud provide perfect protection for the fresh concrete being placed. The concrete does not drop through the water and does not have to displace water when being discharged. The bucket doors close automatically when the bucket is set down for reloading after having been removed from the water. Rated capacities and specifications for tremie concrete buckets are as follows:

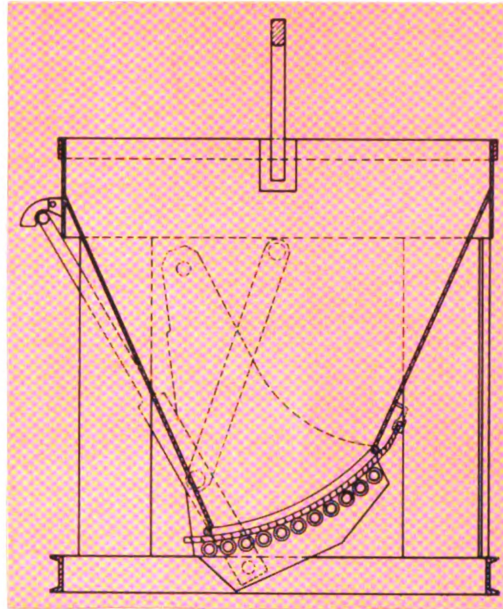
Capacity--cu.yds.	1	2	3	4	6	8
Weight--pounds	1830	2700	3300	5000	6800	8500
Height Open--in.	66	80	91	100	115	134
Ht. Closed--in.	48	56	63	70	80	99
Disc.Area--sq.ft.	10.0	16.0	20.2	25.0	32.0	32.0



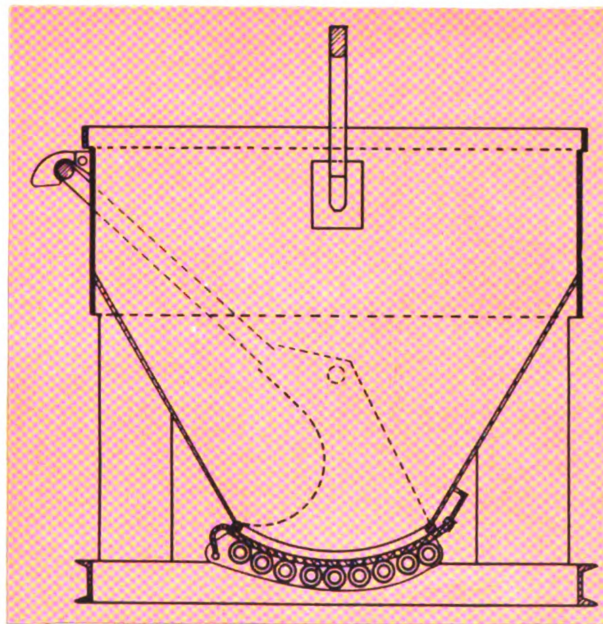
A Double Clam Gate Bucket.



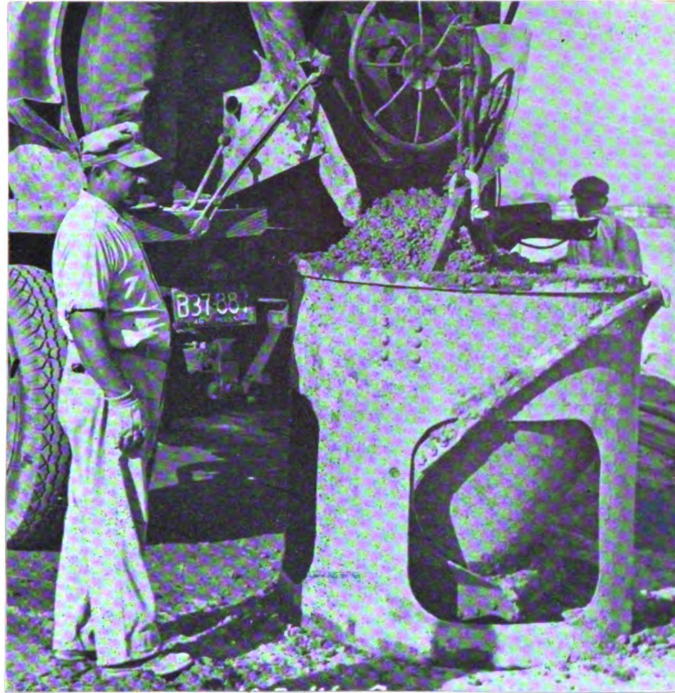
Sketch of Operating Parts.



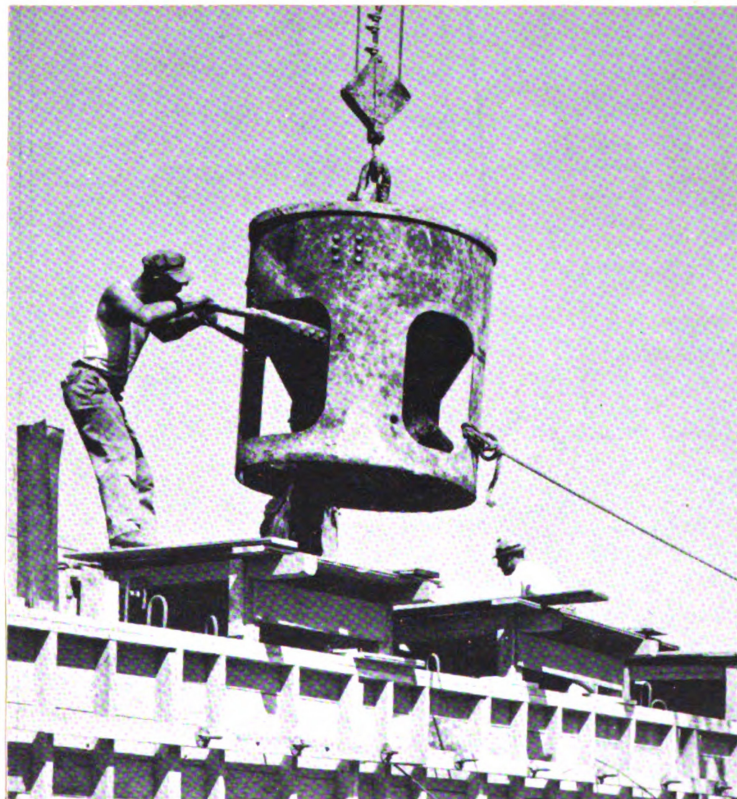
Roller Gate for Low Slump.



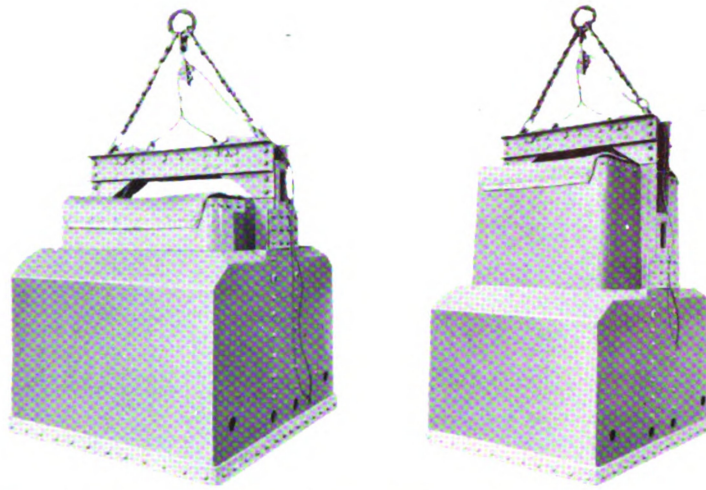
Roller Gate for Normal Slump.



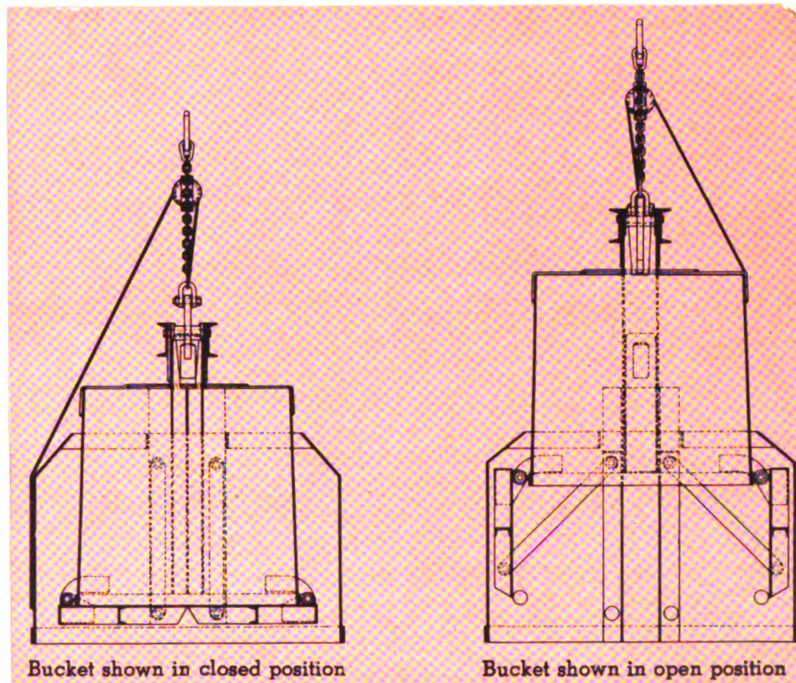
Roller Gate Bucket Being Loaded.



Roller Gate Bucket Being Discharged.



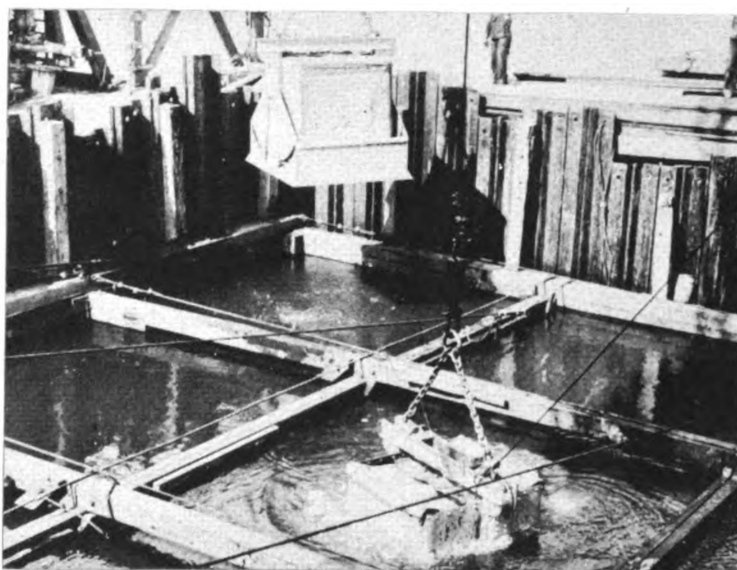
Closed and Open Views of Tremie Bucket.



Bucket shown in closed position

Bucket shown in open position

Schematic Sketches of Tremie Bucket.



Placing Concrete with Tremie Buckets.

PUMPED CONCRETE

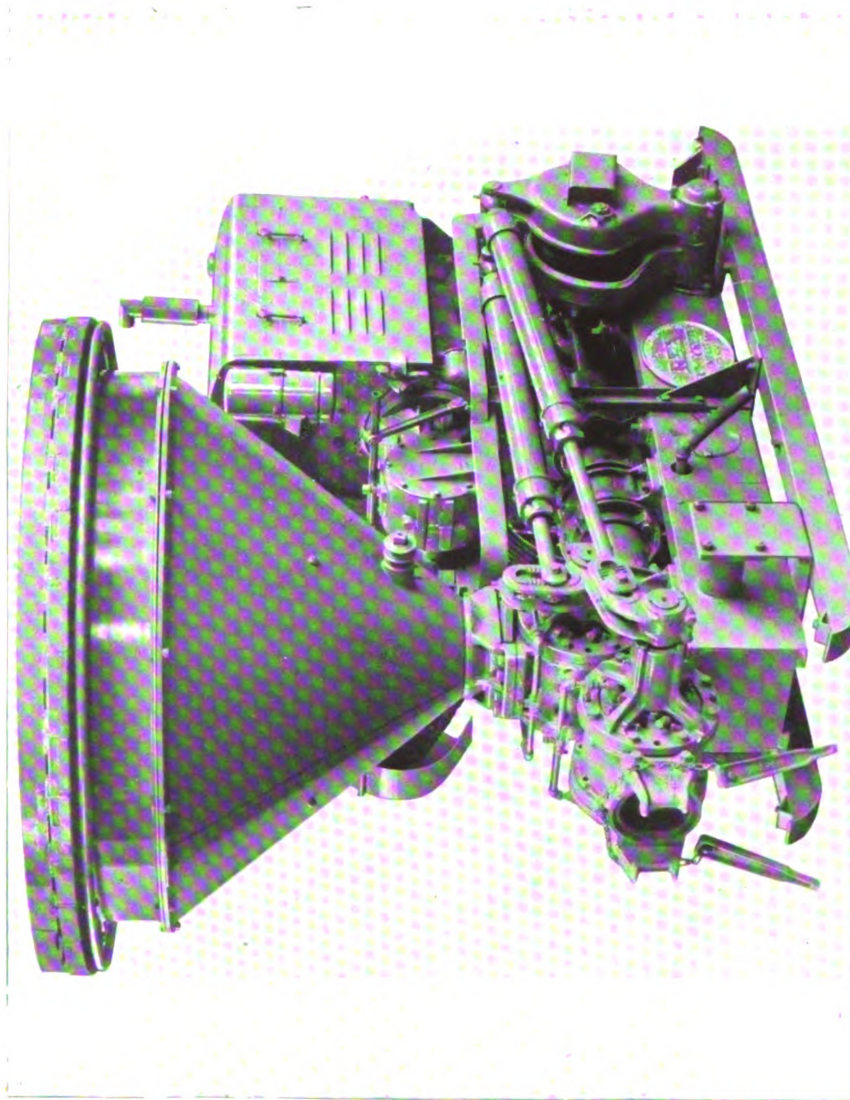
A comparatively recent and unique practice for transporting and placing concrete is the Pumpcrete method. This method consists essentially of a centrally located pumping plant with a pipeline to the delivery point. It does away with the slow, costly, bothersome use of elevators, towers, platforms, runways, and buggies. Pumpcrete equipment finds many applications, usually with substantial savings in expense and labor. Its simplicity also allows greater freedom for other construction activities.

Pumpcrete machines do not do their own mixing, but they do remix concrete with either a conical or a pugmill type mixer before pumping it into the pipeline. The pipelines are either 6, 7, or 8 inches in diameter depending upon the size of the Pumpcrete machine used. The sections of pipe are 10 feet in length and are held together by special quick-opening toggle couplings. Shorter lengths of pipe and a variety of elbows which facilitate the pumping of concrete to any location and in any direction are also available.

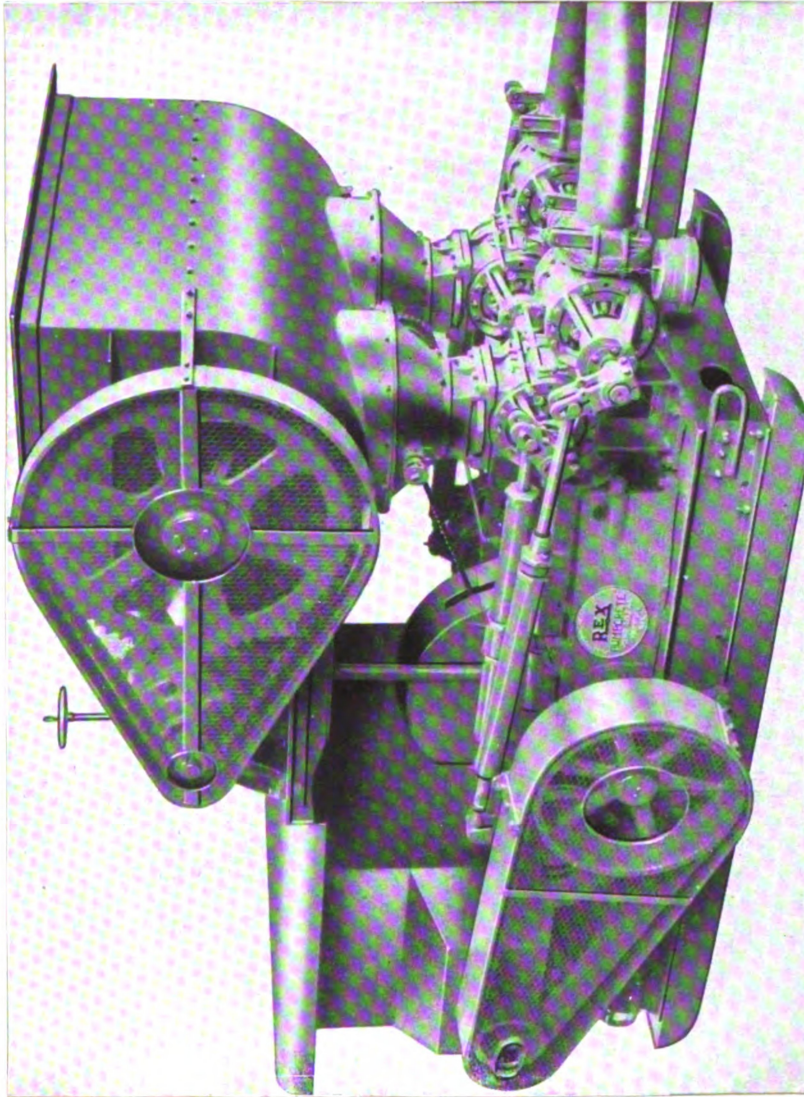
Various sizes of Pumpcrete machines with several output capacities are made ranging from 15 to 65 cubic yards per hour. These machines will handle all common mixes with slumps varying from 1 to 6 inches. The maximum size of aggregate that can be handled is 2 to 3 inches in diameter. It will supply pipelines up to 120 feet in length vertically and 1000 feet in length horizontally. Several double Pump-

crete machines are also made. These machines are equipped with two pumping cylinders instead of one, in order to obtain a larger capacity with a minimum of machinery and operational requirements. These machines, depending upon their size, are powered by 30 to 60 H.P. gasoline engines or electric motors. In the following table, several Pumpcrete machines are listed with their particular specifications.

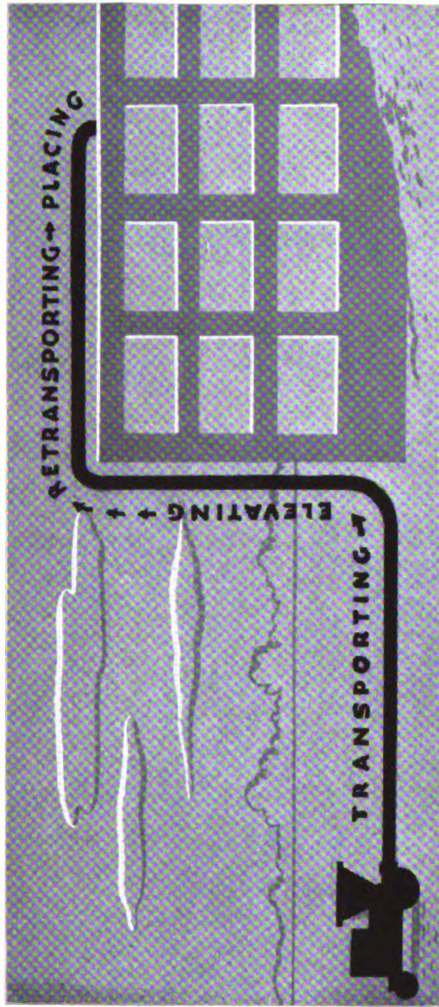
<u>Type</u>	<u>Cylinders</u>	<u>Remixer</u>	<u>Pipe</u>	<u>Capacity</u>
160	Single	Conical	6"	15-20 yds/hr
160	Double	Pugmill	7"	30-40 "
200	Single	"	8"	25-33 "
200	Double	"	8"	50-65 "



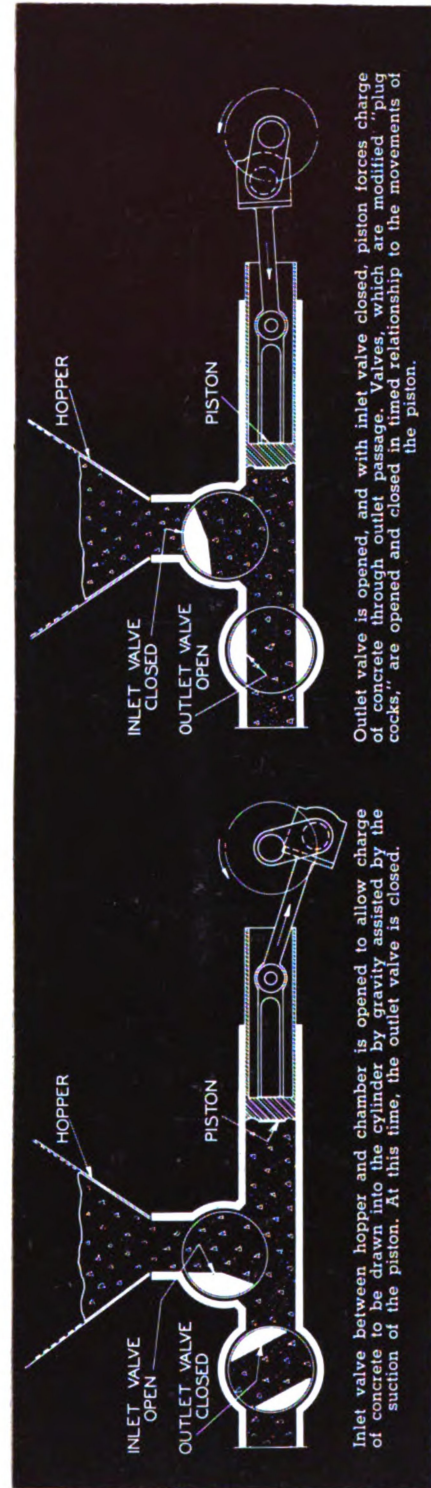
A One Cylinder Pumpcrete Machine with a Conical Remixer.



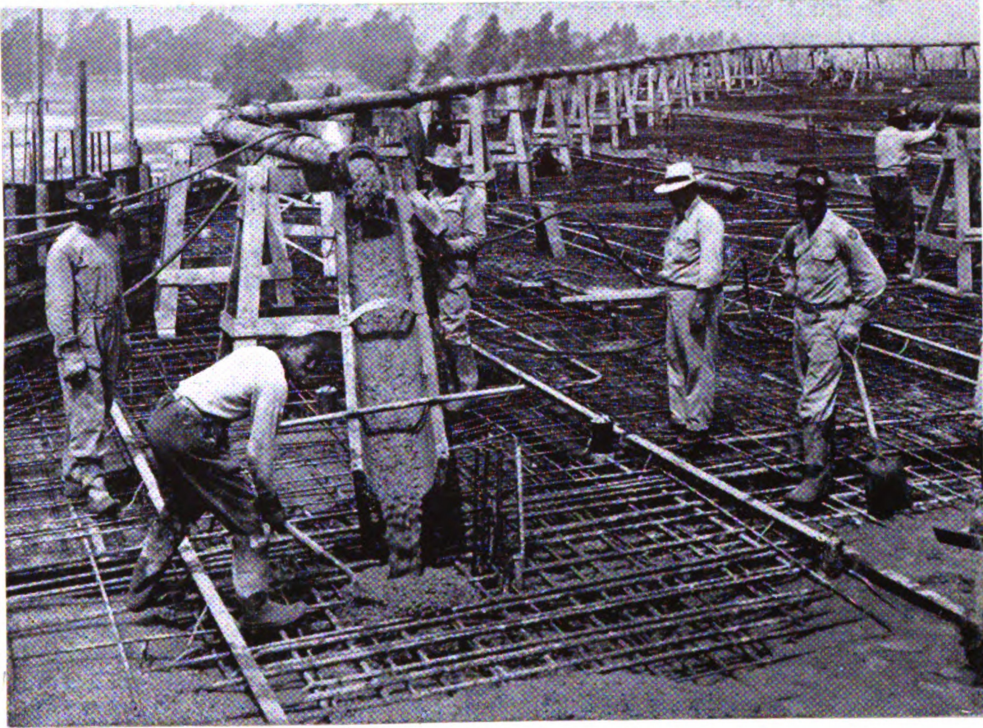
A Two Cylinder Pumpcrete Machine with a Pugmill Remixer.



The Operation of Pumping Concrete.



A Diagram Showing Operation of the Pumping Mechanism.



The Placing of Pumped Concrete.

FORMS

Forms, as the name implies, are used for the purpose of holding freshly poured concrete in place or form until this concrete has taken its final set and can support its own weight. After the concrete has become set up, the forms may be removed, cleaned, and reused or discarded.

There are two types of forms in use today--wood and steel. The use of steel forms in place of wooden ones is becoming increasingly more popular in almost every phase of construction work. In fact, in many instances, building codes and government regulations require the use of steel forms. This is because of the assurance of closer tolerances and truer conformance as to the cross-section of the structure. Steel forms also leave a smoother concrete surface where appearance is an important factor.

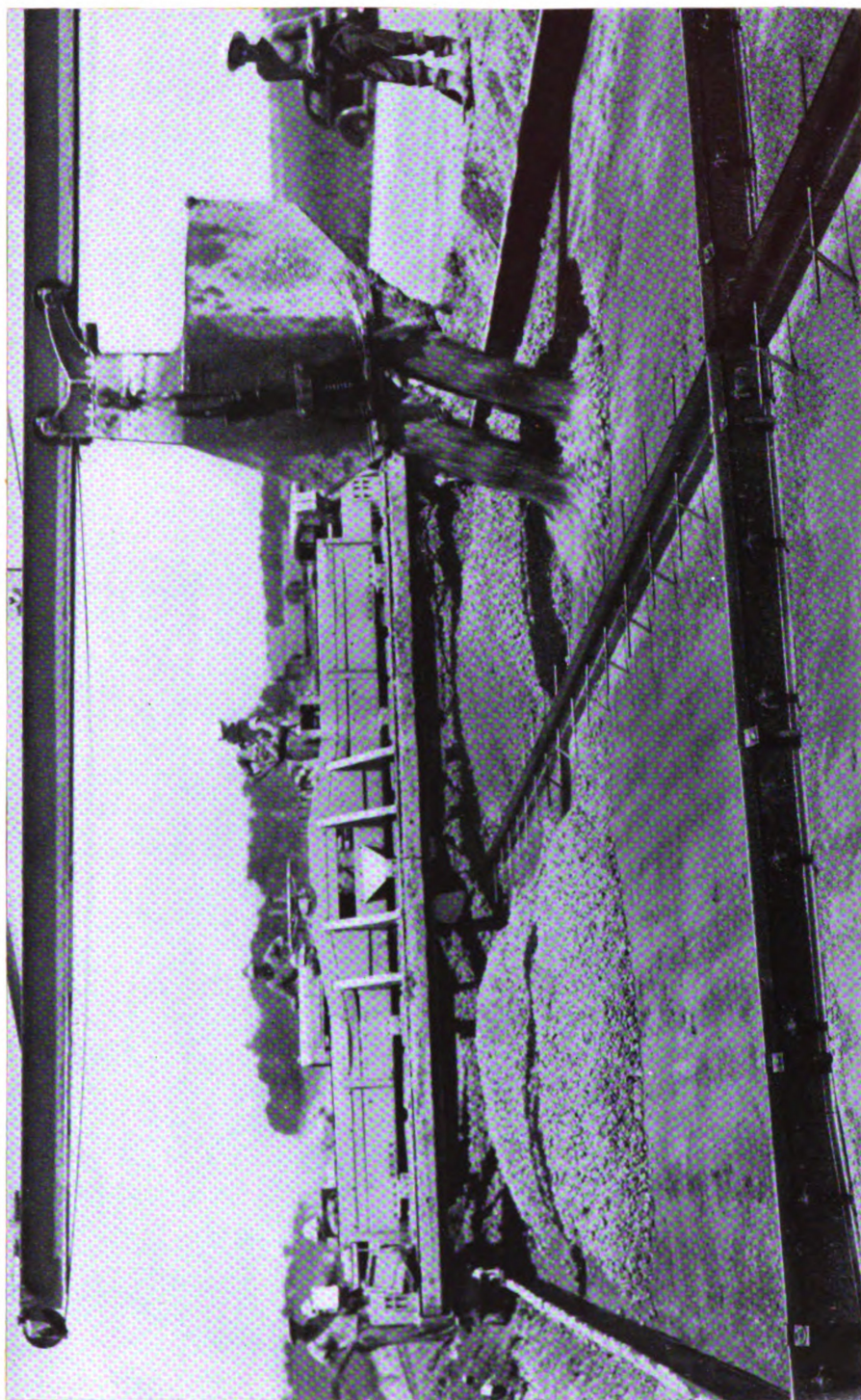
Steel forms are prefabricated from high carbon steel to insure longer life, and are designed for maximum ease of setting, stripping, and cleaning. In the long run, they are cheaper than wood forms, even on small jobs, because of the higher salvage value. Steel forms can be locked together and separated by means of simple key joints, screw latches, or special assembly bolts that greatly reduce the labor involved in form work. Repeating form sections also reduces labor costs and the required number of forms needed for a particular job.



A View Showing Outside Forms on a Sewer.



A View of Inside Forms on the Same Sewer.

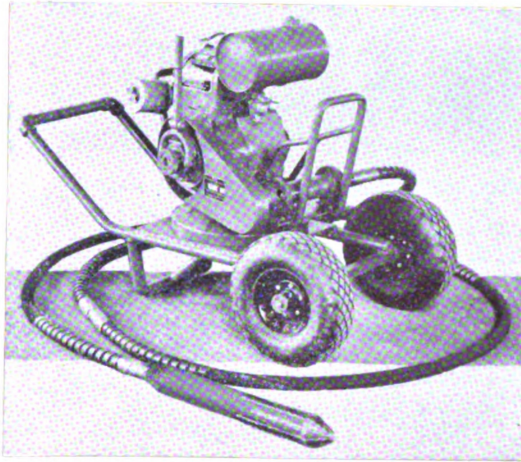


A View Showing Forms and Longitudinal and Transverse Joints.

CONCRETE VIBRATORS

The vibration of concrete is a rather new practice possessing some advantages over hand puddling and is being adopted by more engineers and contractors every day. The engineer is concerned with the increased density and watertightness of the vibrated concrete. This will result in the increased weathering resistance of the concrete, a better bond between successive layers of concrete, and a better bond between the concrete and the steel reinforcing. With the aid of a vibrator in placing concrete, the contractor can use less water, cement, and sand and more coarse aggregate in his mixes and still have a stronger concrete. He also is able to reach inaccessible forms which otherwise would present quite a hand puddling problem. Vibrators handle drier mixes of low workability with no increased difficulty, and still leave a honeycomb-free surface after the forms have been removed.

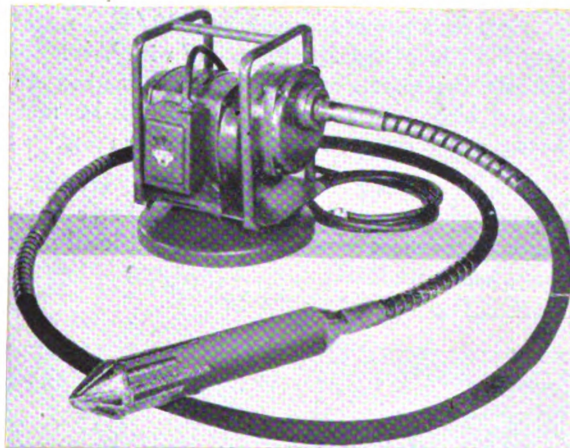
A concrete vibrator consists of a flexible shaft with a vibrating head powered by either a gasoline engine or an electric motor ranging from 1 to 4 H.P. Vibrator units generally weigh between 65 and 170 pounds. They make 4000 to 8000 vibrations per minute but usually operate at about 5000 vibrations per minute.



Vibrator Driven by Gasoline.



A Vibrator Being Used.



Vibrator Driven by Electricity.

SPREADERS AND FINISHERS

Spreaders and finishers are closely related in their operation of molding the concrete placed on the subgrade by pavers or trucks into a finished highway or airport. The concrete finisher was developed about 25 years ago, while concrete spreaders are a comparatively recent development.

Spreaders. The concrete spreader is a rigid frame mechanism which merely replaces the manual labor of spreading the concrete as it is discharged from the paver. The paver can place the concrete anywhere on the subgrade and the spreader will move it both transversely and longitudinally leaving the concrete spread uniformly to the width and elevation required. This machine makes possible higher production, since it simplifies and speeds up the work of the finishing machine.

Most spreaders are composed of the following parts:

1. An automatic transverse spreading blade or a screw conveyor which spreads and pushes excess concrete ahead of the machine.
2. A strike-off screed which shapes the concrete to the desired height and crown.
3. A vibrator which compacts the concrete.

By the use of spreaders, it is possible to handle a much harsher and drier mix of concrete, thus reducing the water-cement ratio and giving a stronger concrete. Spreaders usually come in two sizes--a 10 to 15 foot adjustable

width and a 20 to 25 foot adjustable width. They operate on the steel forms using them as tracks on which the wheels travel. A spreader can usually average between 250 and 350 lineal feet per hour. At this rate it can handle the maximum output of two 34E dual drum paving mixers.

Finishers. Similar in appearance and construction, the concrete finishing machine, like the spreader, is a rigid frame device and travels on the steel forms. Having been developed to such a high degree of perfection, the finishing machine produces a riding surface far superior to that of hand finishing. Also like the spreader, the finisher can make a more rapid rate of progress than is possible by hand labor. In addition it too can handle drier and more harsh mixes of concrete.

The working parts of the finishing machine are usually one of the following different combinations.

1. Single screed in front.
2. Double or tandem screed, one in front and the other some distance behind.
3. Single screed and a vibrator.
4. Double screed with a vibrator between.

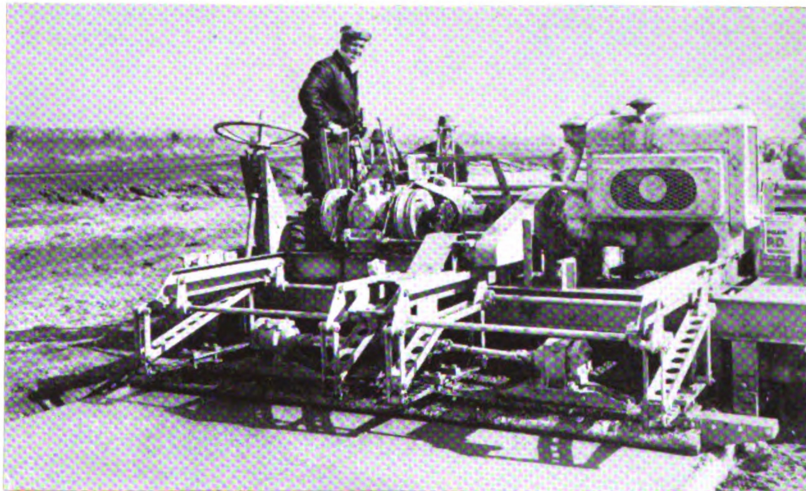
The first screed is a strike-off screed which is needed principally when the finisher has not been preceded by a spreader. The vibrator is used to compact the concrete. Tampers were formerly used in place of vibrators, but were found to bring too much mortar to the surface causing scaling. The second screed has a wide bottom surface and, as it

moves from side to side, is used to knead the concrete as it is brought to the proper crown.

Finishing machines come in a 10 to 15 foot and a 20 to 25 foot adjustable widths for use on one or two lane highways.



Front View of Spreader on 11 ft. Pavement.



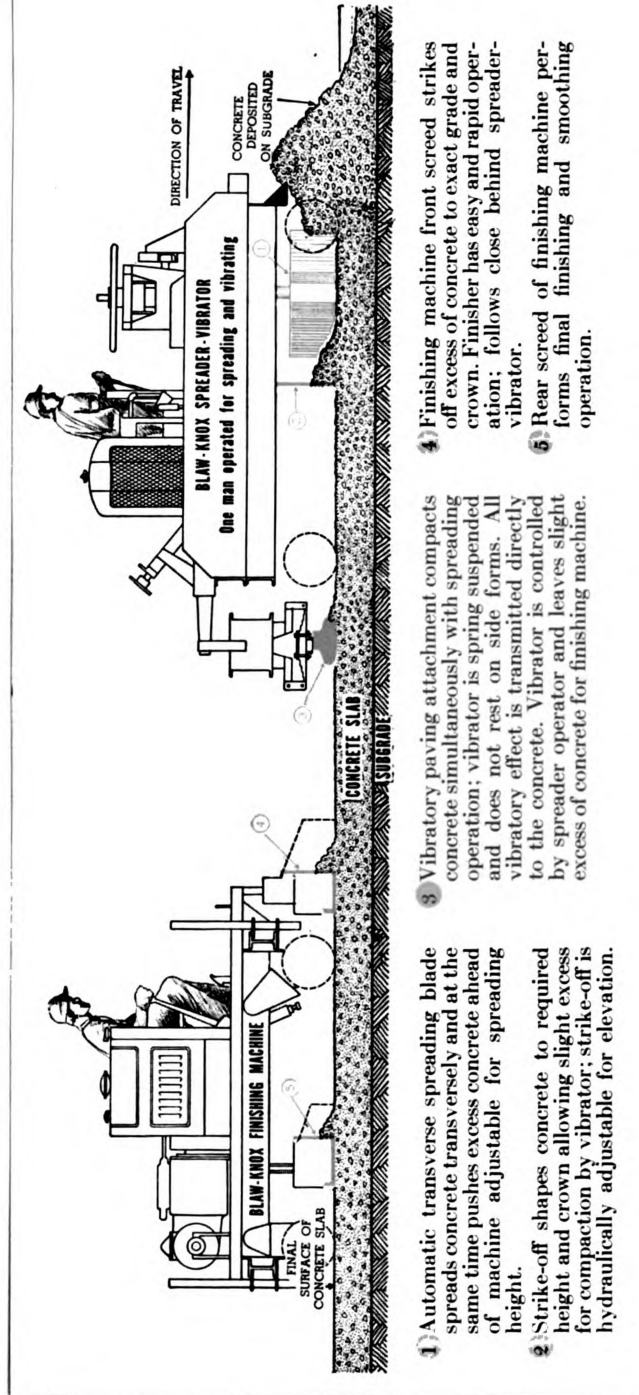
Rear View after Spreader Has Passed.



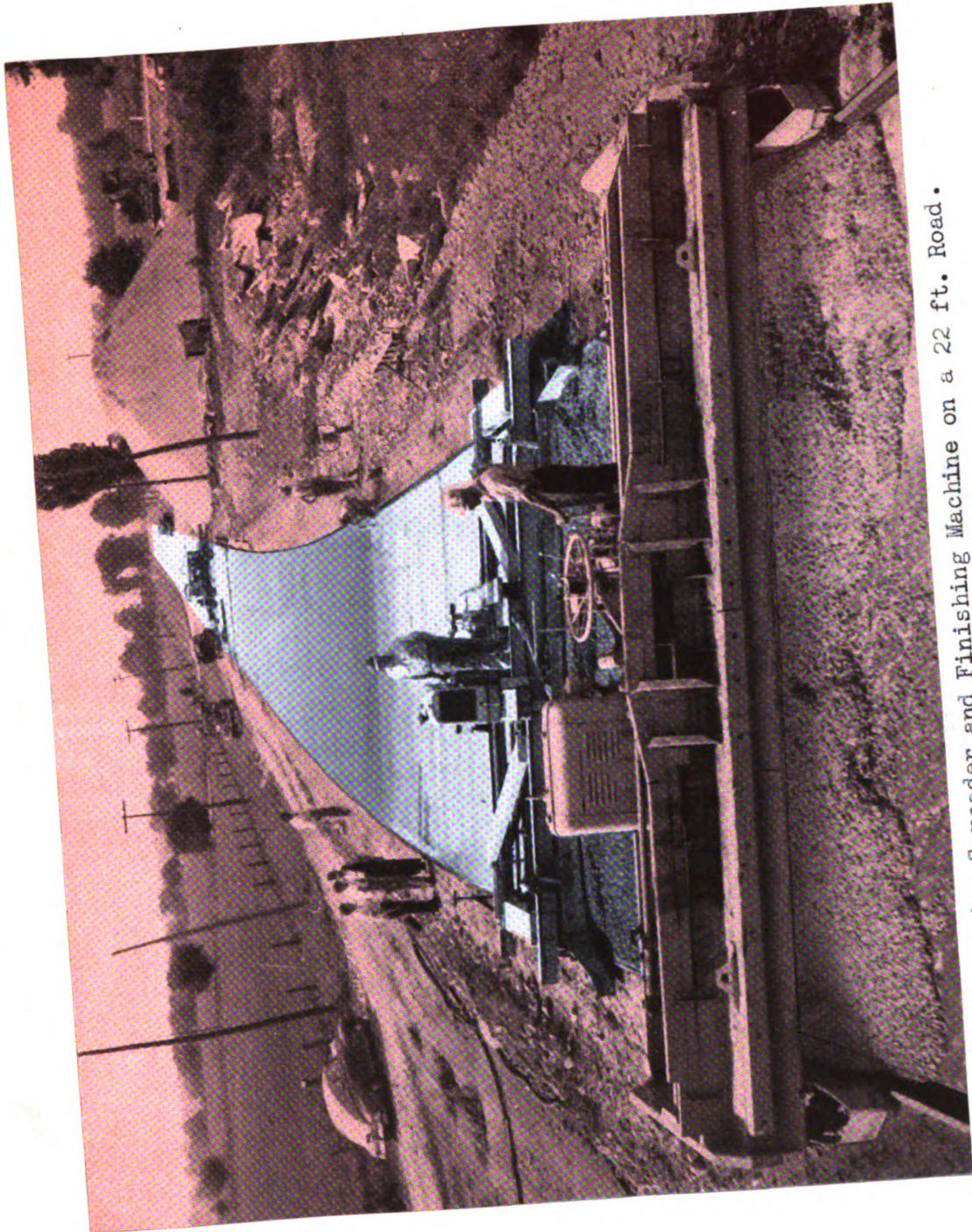
First Pass of a Finisher on 11 ft. Pavement.



Second Pass of Finisher over the Same Surface.



A Diagram Showing Operation of Paving Spreader and Finishing Machine.



Paving Spreader and Finishing Machine on a 22 ft. Road.

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