REPORT OF COMMITTEE ON CHARACTER AND USE OF ROAD MATERIALS

H S MATTIMORE, *Chairman*

Engineer of Tests and Materials Investigations, Pennsylvania Department of Highways

The committee has no formal report on Investigations to offer this year, due to the fact that the members were unanimously of the opinion that the time spent this year would be eventually more fruitful if given over to laying out and preparing a program for future investigation

Consideration was given to some of the suggested problems in the Coordination Committee's report, viz., "cement." At the present time this material has still many unknown qualities The present tendency is to produce a product giving high early strength, and studies of methods by which this is being accomplished, in order to determine durability of the product in concrete, are well worthy of investigation.

Some high early strength cements have been marketed for the past few years, and a large quantity of this product is used in highway work. The present specifications are based entirely on strength tests. It does not seem as though this is sufficient to definitely control this material, therefore, it is considered advisable to form a new subcommittee for the study of Portland cement, and the high early strength cements.

The subject of workability-concrete tests that will indicate the workability in concrete pavements, is important, and although numerous investigations have been made to date, no tests suggested seems fully satisfactory. The committee will keep in contact with future investigations along this line, and report on the status of these studies periodically.

The effect of concrete admixtures to improve the workability is still an open question The committee is of the opinion that no data presented to date indicates that any admixtures are beneficial for this purpose.

A study of the mixing process in concrete is extremely important, but there are not sufficient data available at the present time to indicate what effect this has on uniformity and quality

In the field of bituminous materials and mixtures, we believe organized research should be carried on to determine suitable proportions and characteristics of aggregates for mixed in place bituminous surfaces We also believe that considerable information is desirable on determination and classification of the important characteristics of bitumen for surface treatment and mixed in place surfaces. Subcommittees have been organized to study these problems on bituminous materials.

ACCURACY OF WATER MEASUREMENT ON PAVING MIXERS

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Engineer of Tests and Inspection, Minnesota Highway Department,

AND

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Recent developments in the manufacture of concrete have resulted in great improvements in its quality and uniformity Proportioning aggregates and cement by weight with corrections for the variables which affect the relationship between weight and the solid volume of the materials and for the water which they contain have contributed largely to the recent improvement Development of the water-cement ratio theory of the design of concrete mixtures has called attention to the importance of the accurate measurement of mixing water.

The measurement of that part of the mixing water not contained in the aggregates is ordinarily done by means of equipment furnished by the mixer manufacturer and mounted on the mixing machine. The water measuring equipment furnished with the common type of paving mixer consists of a closed tank connected to a water supply pipe and to a pipe which discharges into the mixer drum. Inside the tank is an adjustable syphon, trough, pipe, or displacement cylinder designed to allow a controlled quantity of water to be drawn from the tank One mixer is equipped with a tank having one movable head by which the total volume of the tank is varied. This tank is completely filled and completely emptied for each batch. The mechanism which controls the position of these adjustable devices is marked to indicate the quantity of water which may be expected to be delivered per batch for any given setting.

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The tank is provided with one or more air relief valves which allow air to enter the tank as water is withdrawn, and allow air to escape as the tank is filled These air valves are intended to allow all the air to escape from the tank and to prevent the escape of water

A control valve is placed in the supply pipe and another in the discharge pipe These two valves are ordinarily linked together so that when one valve is in the closed position the other is open. This arrangement allows the valves to be operated by a single lever and should be designed to prevent the possibility of both valves being open at the same time

The types of tanks and control valves in common use at the time these tests were made (1927 and 1928) are shown in figures 1 and 2. The observations herein reported were made on this type of equipment. It will be noted that accuracy of measurement can be expected from this type of equipment only under the following conditions

1 That the measuring tank is completely filled with water for each cycle of measurement This condition can exist only when no air is entrapped in the tank
2 That there is no opportunity for water to flow from the supply line while water is being discharged from the measuring tank This condition can exist only if the valve arrangement is such that one valve is not opened until the other is closed
3. That the quantity of water remaining in the tank is always the same for any given setting of the indicating device In the horizontal type of tank with an adjustable syphon, this condition will not exist when the tank is tipped due to grade or superelevation unless the intake of the syphon is at the exact center of the tank in both directions for all settings of the indicator If the intake of the syphon is not at the center, accuracy demands the application of an impractically cumbersom correction factor each time the tank is tipped

Believing that the sources of error suggested above actually existed in the ordinary water measuring equipment furnished with concrete paving mixers and that these errors were serious in their magnitude, studies of the accuracy of water measuring equipment were undertaken by the Iowa Highway Commission * and the University of Minnesota * The main sources of variation observed in these studies

* The work done by the University of Minnesota was under the direction of Mr Swanberg The work done in Iowa was under the direction of Mr A E Stoddard

are, (1) variable quantities of air entrapped in the measuring system, (2) overlapping in the opening cycles of the control valves. (3)

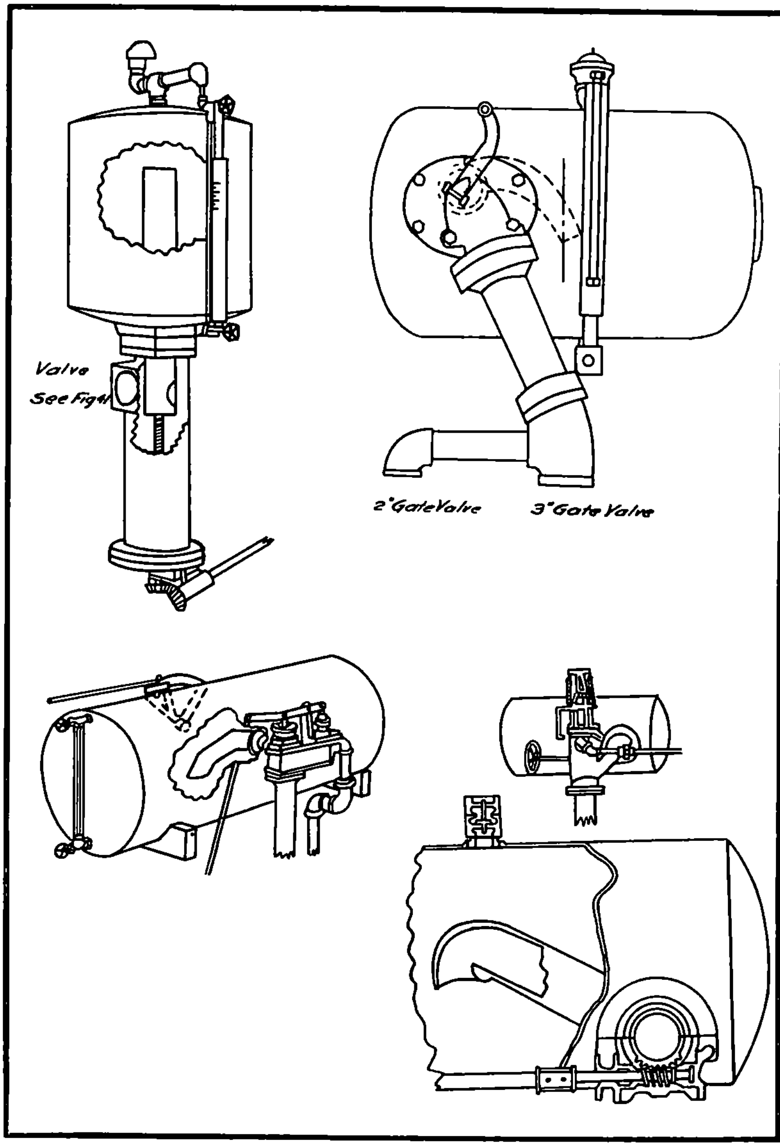

Figure 1. Measuring Tanks 27-E Pavers

variable pressures in the pipe line and (4) the personal judgment of the mixer operator

There are three principal sources from which air becomes entrapped in the water supply for paving mixers (1) Some air enters

the line at the pumps due to leaky pumps and inadequately submerged intakes (2) Some air enters the line at the joints since the joints in the pipe are not all tight and the operation of the pumps is not continuous Air from these sources is likely to reach the mixer in small bubbles, quite uniformly distributed (3) Each time the hose connecting the mixer with the pipe line is moved, a volume of air is admitted into the system All this air is supposed to be eliminated by the air relief valves, but it was observed in these studies that these valves frequently fail to function completely and that they cannot be depended upon to function uniformly under varying conditions such as the quantity of air entrapped and pipe line pressure Any air entrapped in the measuring tank displaces an unknown volume of water from the quantity required for the batch This volume will be inversely proportional to the pressure in the tank at the time the valves are closed.

With the common design of three-way valves and connected gate valves, there was usually a period in their operation in which the intake and discharge valves of the measuring tank were both open. During this interval water flowed directly from the line into the mixer drum. If the speed of operation of the valves were absolutely uniform and the pipe line pressure always constant, the amount of water thus passing to the drum would be constant and could be taken into consideration in regulating the settings of the mechanism controlling the measuring device. In actual practice both of these factors are variable and may combine to increase or decrease this leakage.

Both of the foregoing factors are affected by variations in pressure in the pipe line. With low pressure, air entrapped in the tank occupies greater space than when the pressure is high With high pressure a greater amount of water is passed to the mixer drum in the overlapping periods of operation of intake and discharge valves

In addition to these variables, the mixer operator frequently adds water to the batch at his pleasure by throwing the water control lever over for an additional "Squirt." No doubt this procedure is prompted by the production of "dry" batches resulting from some combination of the variables mentioned heretofore. Such action is not to be condoned because it adds another variable to an already complicated field.

The work of the University of Minnesota, which was conducted in cooperation with the Minnesota Highway Department, was a laboratory study of several types of water measuring equipment in common

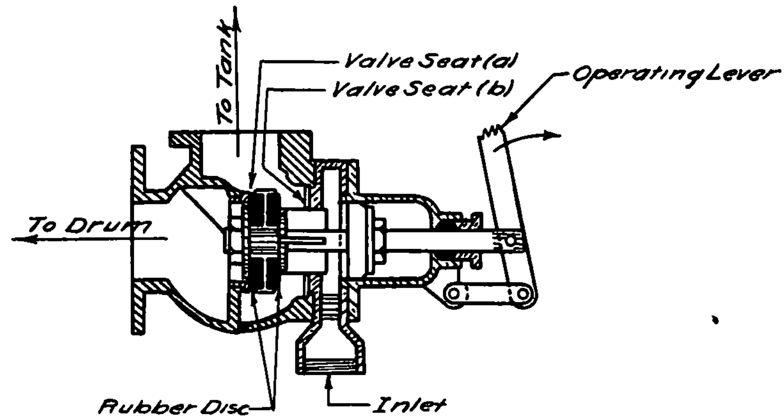

Figure 2 One Type of Three-Way Valve

Note With valve in position shown (left face of rubber disc against seat " a "), the valve is in the " fill " position, and water flows from inlet to the tank

With valve moved to the extreme right so that right face of rubber disc is against seat " b," the inlet is closed and water flows from the tank to the drum.

If valve is at any intermediate position so that left face of rubber disc is not seated as shown, water will flow directly from inlet to drum

This condition is typical of all valves tested.

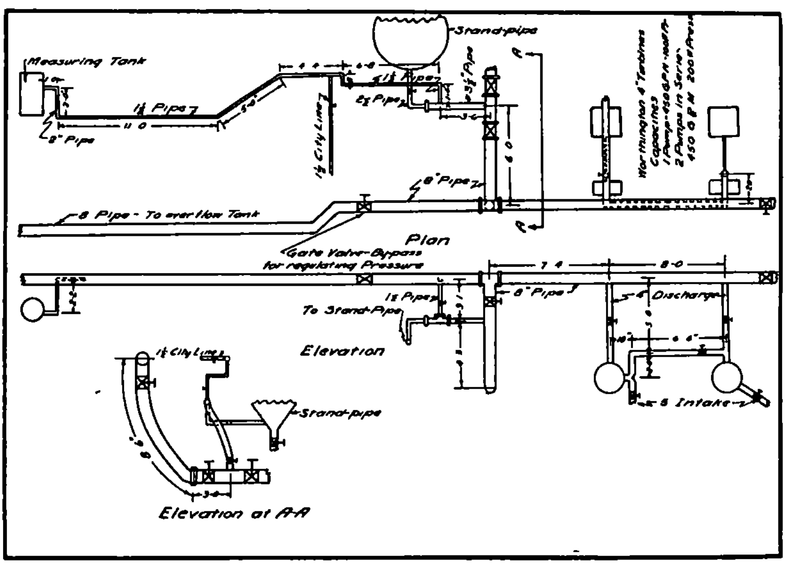

Figure 3. Arrangement of Pumps and Piping for Tests of Measuring Tanks

use This investigation covered the effects of the following variables on four different types of tanks and one meter

1 Accuracy of indicated quantity.
2 Effect of pressure variations on quantity of water discharged.
3. Effect of grade upon the quantity of water discharged
4 Effect of superelevation upon the quantity of water discharged.

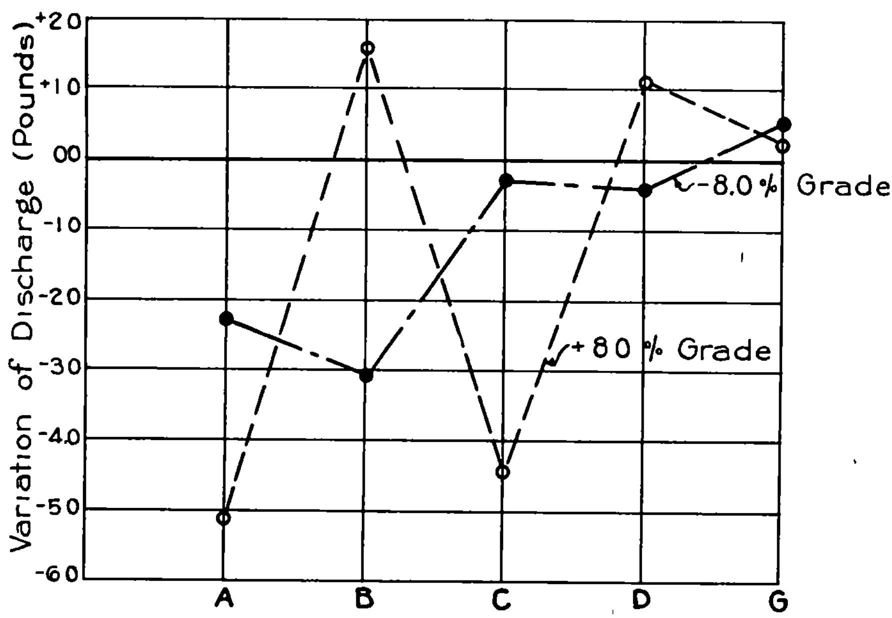

Figure 4 Effect of Grade on Quantity of Discharge

Note Discharge at test setting with 85 lbs pressure and zero grade as follows:

A—20 gallons
B—25 gallons
C—24 gallons
D—25 gallons
G—30 gallons

5 Effect of combination of grade and superelevation upon the quantity of water discharged.
6. Time required to fill tank at various pressures
7. Time required to discharge various quantities of water

For the test each tank was mounted on a segmental frame which permitted adjustment assimilating effects of grade either plus or minus, and effects of superelevation to right of left Water was supplied at the desired pressure by two centrifugal pumps operated

singly or in series Test runs were made at pressures from 30 to 155 pounds as indicated by a gage at the measuring tank The grades used were 0, 4 and 8 per cent plus and minus The superelevations used were 0, 4, 8, and 12 per cent right and left

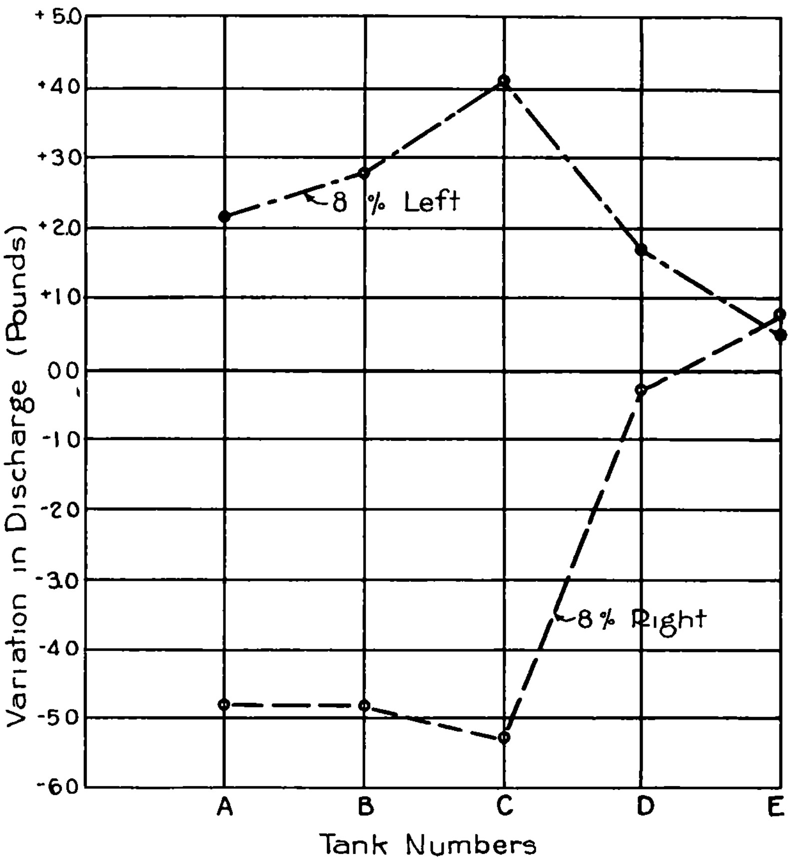

Figure 5. Effect of Superelevation on Quantity of Discharge

Note. Discharge at test setting with 85 lbs pressure and 0.0 per cent superelevation as follows:

A—20 gallons
B—25 gallons
C—24 gallons
D—25 gallons
E—30 gallons

A plus grade was considered as raising the charging end of the paver Right superelevation was considered as raising the right side of the paver, facing the direction of travel.

The indicator of every tank examined was found to be in error by various amounts Variations of pressure were found to have a direct

effect on the quantity of water discharged at different settings Grades and superelevation separately and in combination affected the quantity of water discharged With the piping arrangements and the pressures used the tanks filled and discharged within the customary mixing cycle A summary of the effects of various factors studied is shown in Table I A portion of these data are shown graphically in figures 4 to 7

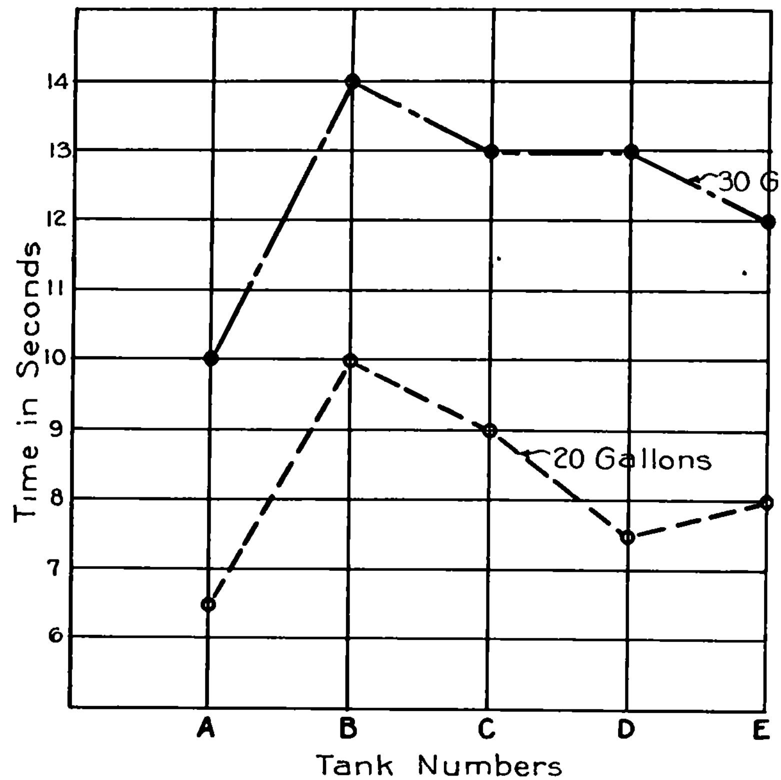

Figure 6. Time of Filling. Pressure 85 lbs ±

It will be noted that the studies made by the University of Minnesota were conducted under controlled laboratory conditions. The equipment studied was furnished by manufacturers for the purpose of this study It should also be noted that this study did not include that of the effect of air entrapped in the water supply

The work of the Iowa Highway Commission was a study of the accuracy of water measurement on paving mixers in operation in the field The measuring equipment had all been in use under field conditions for some time A two-inch water meter of the oscillating

disc type was connected in the water supply line near the measuring tank. This meter was protected by strainers In the water line near the meter and between the meter and the pump were placed an air

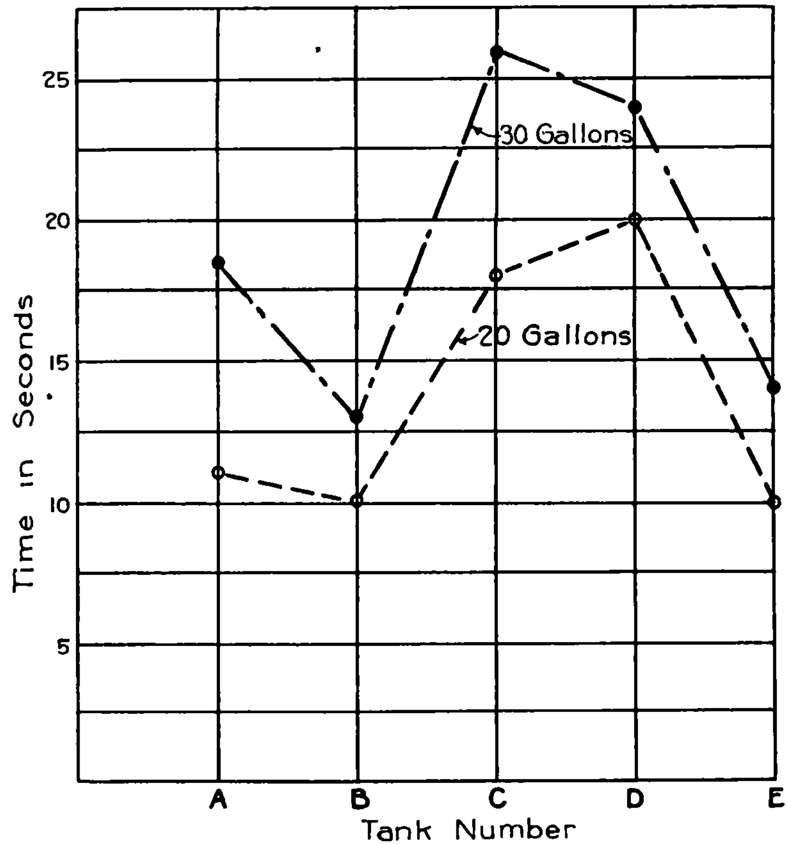

Figure 7 Time of Discharge

Note: Tank "D" discharge
20 gallon setting
169 5 lbs. in 20 sec
171.5 lbs in 25 sec
173 7 lbs in 30 sec
30 gallon setting
252 0 lbs. in 24 sec
253.7 lbs. in 30 sec.
254 9 lbs. in 60 sec

Tank "G" discharge
20 gallon setting
Pressure 29½ lbs 55 sec
Pressure 83½ lbs. 33 sec.
Pressure 152 lbs. 25 sec
30 gallon setting
Pressure 29½ lbs. 81 sec.
Pressure 84 lbs. 50 sec.
Pressure 150 lbs. 38 sec.

relief valve and a pressure gage The air relief valve was designed much like the ordinary steam trap This valve removed the air which was present in the form of large bubbles, but it probably did not remove all the small air bubbles

TABLE I

SUMMARY, EFFECTS OF VARIOUS FACTORS ON ACCURACY OF WATER MEASUREMENT

MINNESOTA TESTS

Tank No	Time to fill	Time to empty	Dial accuracy gal	Discharge lbs increase per lb increase in pressure	Effect of + grade	Effect of — grade	Effect of R super elevation	Effect of L super elevation	Condition for minimum discharge	Condition for maximum discharge	Maximum difference
A	OK	OK	9	034	+	+	+	—	+8% grade 12% R super 30# pressure	—0% grade 12% L super 154# pressure	2.59
B	OK	OK	—	011	+	—	—	+	—8% grade 12% R super 30# pressure	+8% grade 12% L super 155# pressure	2 17
C	OK s	slow	1 91	023	+	—	—	+	+8% grade 12% R super 30# pressure	—8% grade 8% L super 155# pressure	2 07
D	OK	slow	0.3	016	+	—	—	+	—8% grade 8% R super 30# pressure	+8% grade 8% L super 155# pressure	0 625
E			0 35								
F	OK	OK	0.52	016	+	—	—	+	—8% grade 8% R super 15# pressure	+8% grade 8% L super 30# pressure	2 54
G			77	029	0	0	+	+	—	—	0 10

\+ Discharge increased
— Discharge decreased
OK Time is short enough so that it does not slow up the mixer operation

Observations were made on seven different mixers of three different makes in actual operation in the field The period of observation for each mixer was one-half of a working day The amount of water recorded by the meter was observed constantly A record was made of the pipe line pressure at various times during the cycle of operation for each batch of concrete

Starting with the measuring tank full, the discharge valve closed and the intake valve open, it was observed that when the position of the valves was reversed, the meter recorded a flow of water varying in quantity from 0.1 gallon to 3 gallons This indicates that water was flowing from the supply line into the mixer drum during the time both valves were partly open The total quantity that flowed through the valves during their operation varied for the make of mixer and for different mixers of the same make

The detailed results of various tests are shown in Table II

TABLE II

TESTS OF WATER MEASURING EQUIPMENT IN FIELD
IOWA TESTS

Mixer No	No of batches measured	Average leakage, gals	Ave max pressure, lbs	Variation metered batch from calibration setting			Total water per batch		Range of var, gals
				Max	Min	Ave.	Ave gals	Max var from ave	
1	66	0 305	101 0	3 63	0.23	1 543	35.305	2 245	4 00
2	29	0 466	40 0	4 3	0 2	1 641	37 766	3 034	5 50
3	91	0 617	75 8	2 8	0 0	0.866	34 516	2 884	5 60
4	152	1 354	106 6	7 28	0 1	3 691	36.230	4 430	8 70
5	93	Indeterminable	131 6	2 50	0 25	0 663	35 142	3 408	6 75
6	46	0 315	36 3	3 45	0 35	1 933	31 945	2 755	3 90
7	135	0 811	73.5	6 40	0 0	0 949	34 084	5.216	9 10

The results of both of these investigations emphasized the need for improvement and refinement of the design and construction of equipment used for measurement of water for concrete mixers

With the indicator arrangements furnished, it is necessary that each tank be calibrated on the job before the original calibration may be accepted as correct. This criticism applies to all tanks tested during this study It would seem that this error could be easily corrected by the manufacturer and is worthy of consideration

One prominent defect of the measuring devices observed was in the three-way valve, unless this valve was automatically controlled The mixer operator could inject into the mixer drum any additional amount of water, over and above that set on the indicator, by holding the valve lever in an intermediate position between the " fill "

and "discharge" positions. This was possible because both intake and discharge valves were open at the same time and an unmeasured quantity of water was passed from the supply line directly to the mixer drum With rapid operation of the valves this unmeasured quantity is small, but the quantity increased with slowing of the valve operation and increase in pipe line pressure This same criticism applies to connected gate valves not so interlocked as to prevent one valve opening before the other is completely closed.

The quantity of water delivered to the drum was also affected by superelevation and grade This effect was much greater in tanks mounted with the axis horizontal than for tanks mounted with the axis verticle This is because it is practically impossible to design an adjustable draw-off or displacement device which will provide for the delivery of a constant quantity of water from a tank whose axis is horizontal for all normal positions of the tank and all settings of the control device

The effect of variations in pipe line pressure may be eliminated by interposing a supplementary tank open to the atmosphere from which the water will be fed to the measuring tank by gravity. The air entrapped in the measuring tank may be removed by substituting for the air relief valves a riser pipe with a height equal to that of the top of the supplementary tank

Such an arrangement of supplementary tank open to the atmosphere from which the measuring tank was fed by gravity and with a riser pipe substituted for the air relief valve was used on about 60 paving mixers in Iowa during 1929. The flow of water from the pipe line into the supplementary tank was controlled by a float valve. The flow of water from this supplementary tank to the measuring tank and from the measuring tank into the mixer drum was controlled by the ordinary three-way or connected gate valves. This arrangement was very satisfactory in every respect Figure 8 shows a diagrammatic sketch of such an arrangement

This arrangement not only allows air which is entrapped in the water supply to escape as it is discharged into the upper tank, but it prevents the possibility of air being held in the measuring tank due to faulty operation of air relief valves This arrangement also relieves the control valves from excessive pressure which is a frequent source of trouble.

Since it would be very difficult to arrange any method for measuring the amount of water actually delivered to the mixer drum

while the paver is in operation without hindering the work, such data are not available. However, it was the opinion of all engineers, inspectors and contractors interviewed that this equipment gave much more uniform measurement of water than did the ordinary single closed tank.

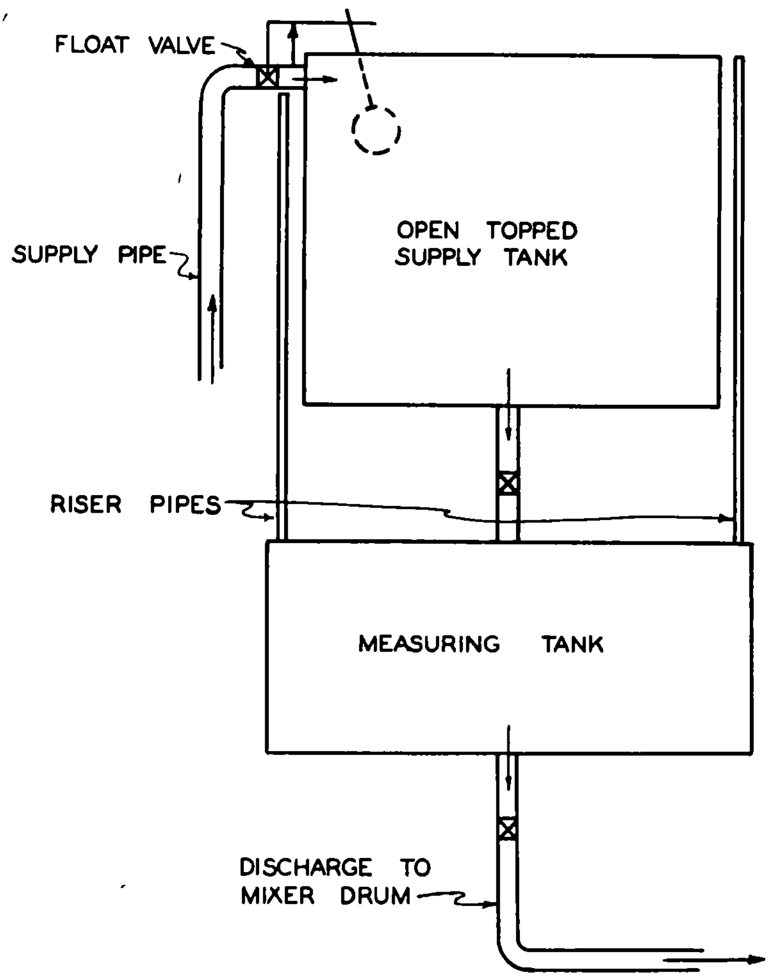

Figure 8. Diagrammatic Sketch Showing Volumetric Measurement of Water under Atmospheric Pressure

The only difficulty encountered was that the float valve controlling the flow of water into the supply tank sometimes failed to close This caused water to overflow onto the ground However, since this was a source of irritation to the contractor rather than a source of defects in the work, the results were not serious and the trouble was corrected promptly

The leakage of three-way valves may be reduced by equipping the plunger with follower skirts which will not clear the intake port before the discharge port is covered and vice versa Gate valves may be interlocked so that they cannot both be open at the same time. With these revisions, the designs of tanks studied would measure water with reasonable accuracy Present design tends toward mechanical operation of the valves This should promote uniformity of water measurement

One other improvement in connection with the operation of valves that may be worthy of consideration would be to arrange the mechanism so that it would be difficult for the operator to introduce into the mixer drum a quantity of water in addition to the measured quantity or make it impossible to do this without the knowledge of the inspector

In justice to the mixer manufacturers, it must be said that they have taken note of the results of these studies and have made many of the improvements suggested Valves have been improved to prevent the passing of water directly from the pipe line into the mixer drum. Vertical tanks have been substituted for horizontal tanks Indicating devices have been improved and several manufacturers are prepared to furnish mixers equipped with supplementary tanks so arranged that water is fed to the measuring tank by gravity and a riser pipe open to the air is substituted for air relief valves

Improvements which will eliminate the principal sources of error in water measurement can be made on mixers now in use at a nominal expense It is suggested that the highway engineer will find it profitable to devote some attention to securing such improvements. The enforcement of specifications requiring accuracy of water measurement will no doubt stimulate further improvements in the design of water measuring devices.