MEASUREMENT OF AUTOMATIC SPRINKLER DISTRIBUTION

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1920

INVESTIGATION OF THE DESIGN OF APPARATUS FOR THE MEASUREMENT OF AUTOMATIC SPRINKLER DISTRIBUTION

A THESIS

PRESENTED BY

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TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE

IN

FIRE PROTECTION ENGINEERING

MAY 27, 1920

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CONTENTS.

ACKNOWLEDGMENTS.

The writers are greatly indebted to Professor J. B. Finnegan, Mr. O.L. Robinson, and to Mr. R. W. Hendricks and Mr. Edward B. Benjamin of Underwriters' Laboratories for valuable suggestions pertaining to the design of this apparatus.

The writers take this opportunity of expressing their appreciation for these favors.

PREFACE.

Previous to this time the problem of designing apparatus for the determination of the distribution of water from an automatic sprinkler has been worked out on two occasions.

Both times apparatus has been designed by means of which this distribution could be accurately obtained. The first apparatus consisted of 144 pans, each one foot square at the top and one foot in depth, a device for exposing the pans to the water from the sprinkler head for a definite length of time, and a calibrated tank for measuring water to one-twentieth of a gallon.

The second design consisted of a series of 12 pans mounted on a sector of a circle, 7.5" in radius and sub-tending an angle of 45 degrees, and a device for exposing each pan for a definite length of time. In place of measuring the water in each pan the weight of each pan empty was known, and after the test the amount of water in each pan was ascertained by weighing.

Time has shown that neither of these methods is feasible, inasmuch as neither method is in use at present. The reason for this is because both sets of apparatus are such that the measuring of the distribution of water from an automatic sprinkler is a very cumbersome and tedious test, requiring at least 1-1/2 to 2 hours time for a single run.

The need of some apparatus by means of which the distribution can be obtained in a much shorter time and with much less tedious work is very evident. The design of such apparatus is the object of this investigation.

CHAPTER I.

INTRODUCTION.

At the beginning of this investigation it was decided that, if apparatus could be designed which could eliminate the necessity of having to handle each pan after each run, the tedious and cumbersome part of the test would be eliminated. This would require two designs: first, an instrument for measuring the amount of water in each pan; second, some means of draining the water from each pan other than by dumping each one individually.

Owing to the fact that the first design of apparatus with the 144 pans required that the actual run of water from the sprinkler head be only 1/8 the length of time that the sector method required, it was decided to try to design apparatus to use with these pans.

In all, three pieces of apparatus were designed and tried out before obtaining a device which would give accurate and satisfactory results.

The base A Fig. I of the first instrument was designed to sit on the tops of the pans. A hole, 3/4" in diameter was based in the middle of the base to take a wooden upright 22" long. A semi-circular wooden arc "B" was nailed to this upright as shown. A cork float "C" 2" in diameter was fastened by means of a stiff wire to a movable member "D" 12" long. This member was pivoted to the upright to give a 3 to 1 ratio.

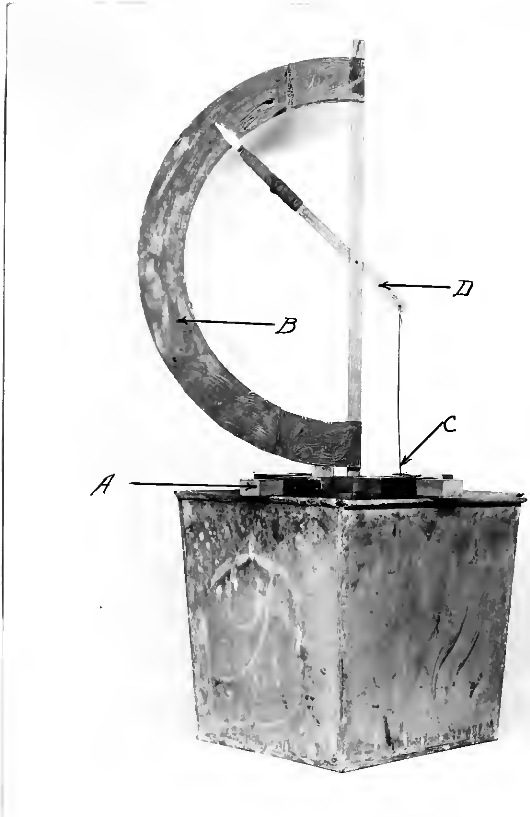

Fig. I

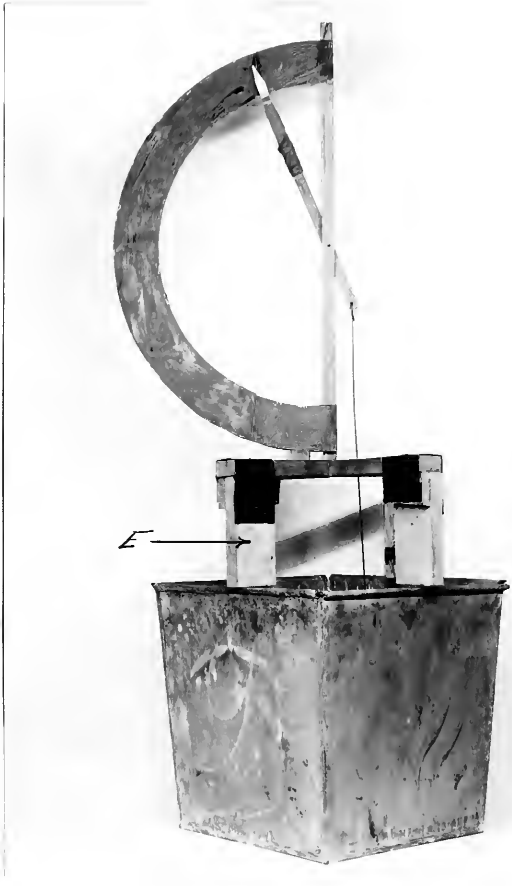

Fig. I'

C H A P T E R II.

Owing to the fact that the instrument as first designed would measure depths of water in the pans up to only 5-1/2", it was necessary to design some means of measuring larger quantities. Movable block SE, Fig. I',3"x1"x5" long were fastened to each of the four pieces of the base in such a way that, when not in use, they could be moved in so that they would be inside the pan. When it was necessary to use them, they could be moved out to the edge of the base so that the instrument would set on them. The pointer was then redesigned so that it could be read on either side of the arc. The other side would be calibrated to read the quantity of water in the pans from 5-1/2 to 10-1/2".

The question then arose as to whether or not the pans were made with sufficient uniformity for one instrument to give accurate readings on all pans. In order to investigate this question ten pans were picked at random and the instrument was calibrated in 1/2 gallon increments from 1/2 gallon

up to 5-1/2 gallons. The amount of water necessary to make up the difference between the minimum and maximum position of the pointer for corresponding increments was obtained by actual test on a set of scales. Working under the supposition that a mark half way between the minimum and maximum would be taken in the final calibration, the maximum percentage error that would result by doing this was worked out for each increment. (Table I)

This error for the lower readings was too large. It was noticed, however, that the error was not due as much to the non-uniformity of the body of the pans as it was to the unevenness of the top edge.

T A B L E I.

Reading.	Maximum Lbs.	Maximum Ozs.	Minimum Lbs.	Minimum Ozs.	Diff.	Average.	% Error.
.5	12	14.5	12	5	8.5	4.25	6.4
1.0	17	3	16	10	9	4.5	3.4
1.5	21	5	20	13	8	4.0	2.0
2.0	25	10.25	25	0	10	5.0	1.9
2.5	29	11	29	2.5	8.5	4.25	1.28
3.0	33	15.5	33	8	7.5	3.75	.95
3.5	38	1	37	4.5	12	6	1.29
4.0	42	6.5	41	8.5	14	7	1.31
4.5	46	6.5	45	8.5	14	7	1.17
5.0	50	10.5	49	12.5	14	7	1.05
5.5	54	7	53	9	14	7	.96

N O T E:

"Reading"- The instrument reading in gallons.

"Maximum"- The gross weight in lbs. and ounces of pan, instrument and water to give the maximum reading as given by any pan for this increment.

"Minimum"- The gross weight in lbs. and ounces of pan, instrument and water to give the minimum reading as given by any pan for this increment.

"Difference"- The difference in ounces between the maximum and minimum reading.

"Average"- The difference in ounces between a point taken half-way between the maximum and minimum reading and either the maximum or minimum reading.

C H A P T E R III.

The primary idea in the second design was to make an instrument working on the same principle as the first one with sufficient changes to eliminate the undesirable features.

The base of this instrument was made so that it would set on the bottom of the pan. This necessitated that the length of the upright member (A Fig. 2) be increased 12". The arc (B Fig. 2) on which the reading would be obtained was made of No. 20 galvanized iron with paper fastened on each side to allow marking. The indicator (C Fig. 2) or pointer was made of much heavier material. The indicating end was cut in such a way that readings could be obtained on both sides of the arc. The float and wire connection were the ones used in the first design.

In making the first tests it was observed that in placing the instrument in the water, the water was distrubed to such an extent that it was impossible to obtain an instantaneous reading. For that reason the base was redesigned in the form

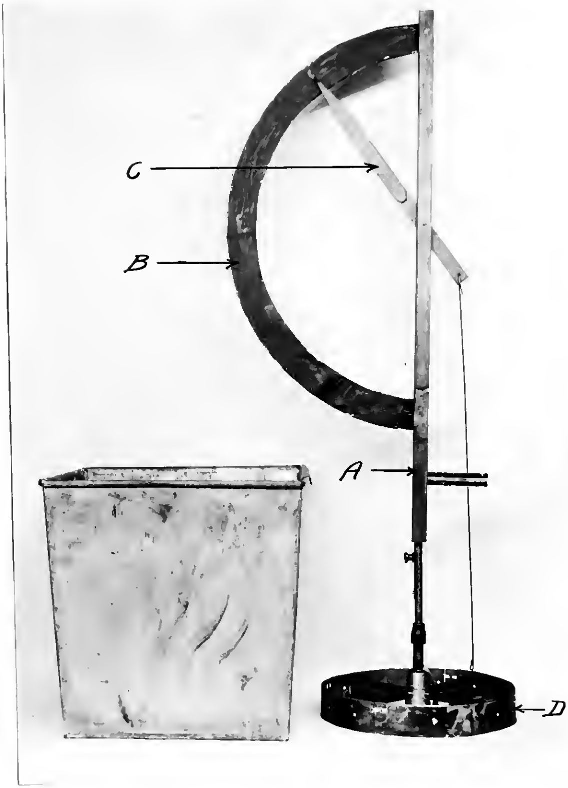

Fig. II

of a wheel. (D Fig. 2) With this arrangement there was a minimum amount of disturbance.

It was now necessary to design some attachment whereby depths greater than 5-1/2" of water could be measured. A design for a telescoping base was first worked out and tried. This proved a failure, due to the fact that it slowed up the process to a marked extent and that it made the instrument very awkward to handle. The following arrangement, however, was worked out, tried, and proved a success. The wooden upright was removed from the hub, the hub was tapped and a piece of 1/4" pipe (E Fig. 2) 8" long was screwed into it. Eight inches was cut off the bottom of the upright, the end was bored to a depth of 2" to take a piece of Bessemer steel rod (F Fig.2) 1/4" in diameter. A piece of 1/4" Bessemer steel rod 9" long was taken and two small holes bored through it 5" apart, the first one being 2-1/2" from one end. A groove 1/8"x3/32" was then cut in the rod running from hole to hole. The piece of 1/4" pipe mentioned before was bored 1/2" from the upper end with a 1/16" hole

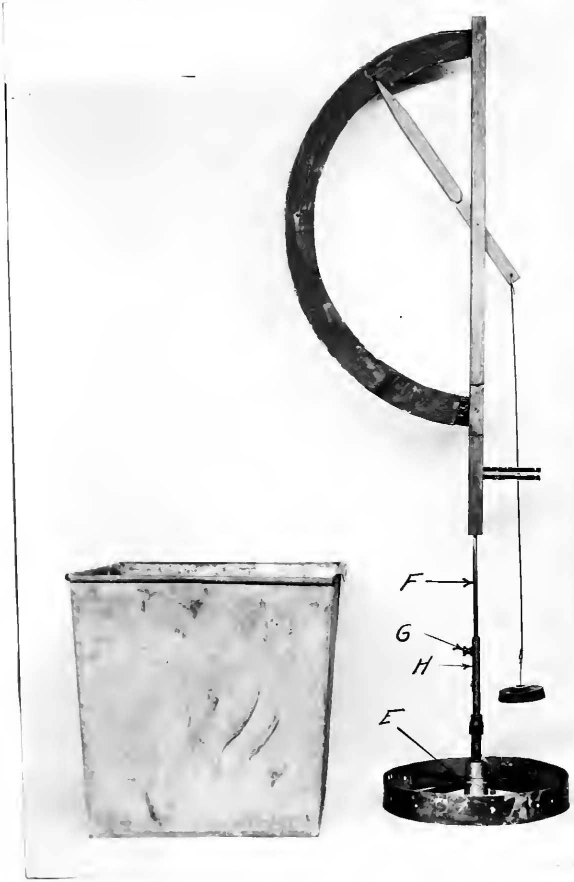

Fig. 2'

in which a pin, (G Fig. 2) which extended 3/16" into the pipe was held in place by a flat spring. (H Fig. 2). One end of the rod made a tight fit into the end of the upright, the other end fits into the 1/4" pipe.

By this means, when the pin was in the top hole in the rod, quantities of water up to 5-1/2" in the pan could be measured, the readings being taken on one side of the arc. To measure quantities between 5-1/2" and 10-1/2", the pin would be pulled out far enough to permit the rod to move. The pin, following the groove would allow the upright member to be raised until the end of the groove was reached when the pin would drop into position in the other hole, thus fastening the upright in this position.

The same procedure as described with the first design to test for the uniformity of the pans was repeated. This time, however, the calibration of the ten pans was only carried up to 2-1/2 gallons, inasmuch as the previous test had shown that from this point on the percentage error was decreasing. (Table, II)

T A B L E II.

Reading.	Maximum Lbs.	Maximum Ozs.	Minimum Lbs.	Minimum Ozs.	Diff.	Average.	% Error
.5	12	3.5	12	0	3.5	1.75	2.5
1.0	16	5.5	16	1	4.5	2.25	1.65
1.5	20	9	20	5	4.0	2.0	1.05
2.0	24	13.5	24	8.5	5.5	2.5	1.03
2.5	28	15	28	8.5	5.5	2.75	.8

This instrument, although workable, and fairly accurate, had some bad features which it was thought would interfere with the speed at which it was desired to run the test. For instance,- the float from time to time became caught on the base and would not function. The fact that the instrument was such that two settings were necessary added to its complications, and increased the time element of the test. For these reasons it was decided to try to work out a third design which would have all the good points of the previous instrument, but none of the points which added to its complication, or the time of the test.

C H A P T E R IV

In the third design a wooden disc (A Fig.3) 15" in diameter and 1/2" thick was supported on its edge by three legs (B Fig. 3) of 1/4" iron rods spaced so that they would rest in the bottom of the pan. A double bearing (C Fig. 3) was mounted at the center of (A) at the back. A wooden pulley (D Fig. 3) fastened to a small shaft was mounted here and kept so that it would not move horizontally by means of a block and pin (E Fig. 3) This pulley was flanged and was constructed to give a 11-1/2" circumference inside the flange. A pointer (F) was fastened to the rim of the pulley. This was of sufficient length to give a 4 to 1 ratio in the readings. It was found necessary to counterbalance the pulley on the side opposite the pointer. This was done by drilling a hole in the face of the pulley and filling it with solder. (K Fig. 3)

Two strands of No. 30 enameled copper wire, twisted together for added strength, were passed around the pulley 1-1/2 turns. A cork float

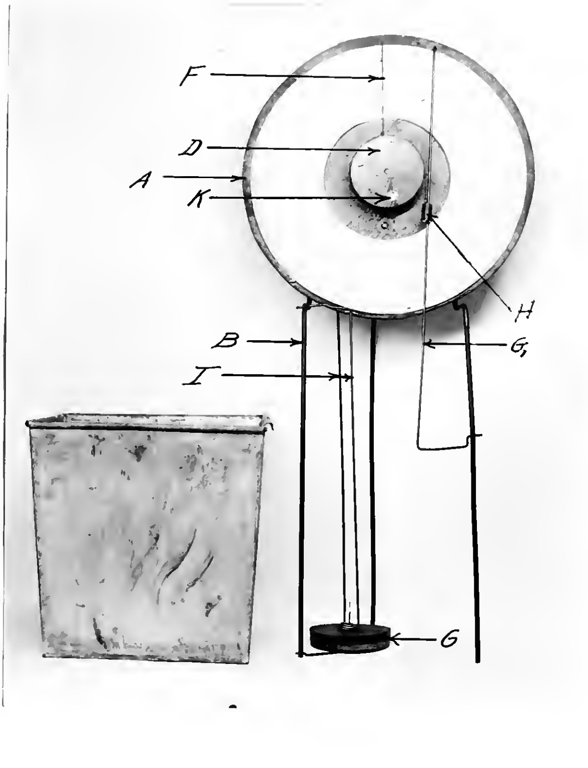

Fig. 3

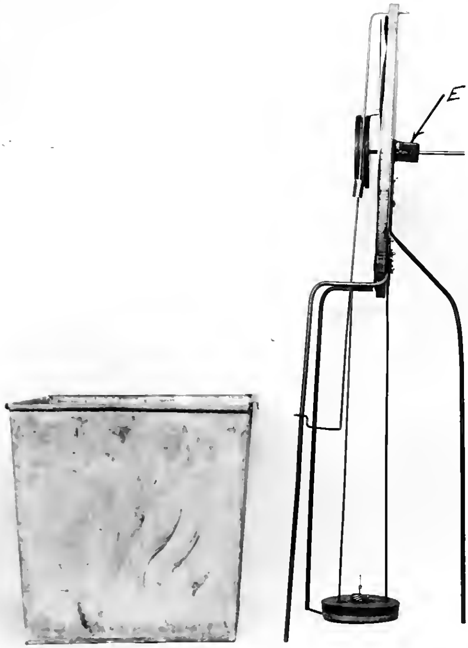

Fig. 3

(G Fig. 3) was fastened to one end of the wire and a counterweight (H Fig. 3) was fastened to the other. The cork float, as it functions, is guided by two small rods (I Fig. 3) of Bessemer steel each of which passes through a hole in the cork. The counterweight is also guided by a similar rod (G1). The wire is fastened to the pulley by a small nail so as to prevent slipping of the wire on the pulley.

The same proceeding as described with the first design to test for the uniformity of the pans was repeated. The results and the action of the instrument were such that it was decided to proceed with its calibration. (Table III)

A paper dial was cut out and fastened to the frame (A) by means of thumb tacks. It was decided that owing to the fact that all pans did not give the same reading on the instrument for corresponding half-gallon increments, the calibration would have to be done with two pans, one which gave the maximum reading, and the one which

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TABLE III.

Reading.	Maximum Lbs.	Maximum Ozs.	Minimum Lbs.	Minimum Ozs.	Diff.	Average.	% Error.
.5	14	3.5	13	15.5	4	2	3.0
1.0	18	9.0	18	4.5	4.5	2.25	1.65
1.5,	23	6.5	23	0	6.5	3.25	1.62
2.0	27	15	27	11	4.0	2.0	.8
2.5	32	3	31	13.5	5.5	2.75	.9
3.0	36	6	35	15	7	3.5	.82

gave the minimum reading. Then the final calibration taken would be a point midway between the readings given by these pans. The pans were first weighed, and then the instrument was calibrated in 1/10th gallon increments up to 6 gallons. The calibration dial was definitely marked with regard to its position on the frame. It was then removed and a scale drawn in ink to read to .01 of a gallon. The scale was then replaced.

Twentyfour pans were selected at random, weighed,and marked. An unknown quantity of water was placed in each pan. This quantity was measured by means of the instrument and tabulated. Each pan was again weighed and the actual amount of water in it calculated and tabulated. The maximum error made by the instrument was.037 gallon, the minimum .001 gallon, and the average error .016 gallon. (Table No. 4)

This last instrument showed a great improvement over the previous ones, inasmuch as

T A B L E IV.

Pan No.	Weight Empty Ozs.	Weight With Water Ozs.	Amount of Water Gals.	Instrument Reading	Gals. Error.
1	101.25	356.25	1.913	1.924	.011
2	105.75	186.5	605	60	.005
3	96.5	317.0	1.654	.672	.018
4	103	324.5	1.662	1.641	.021
5	101	334.0	1.748	1.759	.011
6	99	223	.931	.915	.016
7	98.5	239.5	1.058	1.032	.036
8	100.5	437.0	2.524	2.56	.036
9	99	428.0	2.468	2.457	.011
10	99.5	261.0	1.204	1.228	.024
11	96.5	355.0	1.939	1.923	.016
12	100.0	234.5	1.008	.978	.03
13	100.0	232.5	.997	.987	.01
14	98.0	391.0	2.19	2.153	.037
15	101.5	315.5	1.605	1.63	.025
16	100.0	419.0	2.393	2.407	.014
17	103.5	168.0	.483	.488	.005
18	99.0	169.0	.525	.512	.013
19	102.0	175.5	.551	.555	.004
20	99.0	155.0	.420	.417	.003
21	101.0	244.5	1.076	1.075	.001
22	101.5	275.5	1.305	1.307	.002
23	100.0	324.5	1.684	1.662	.022
24	100.5	224.0	.926	.928	.002

it practically gave an instantaneous reading, only one scale was necessary, and a larger ratio was obtainable on the scale.

The results obtained with this last instrument were such as to convince the writers that they had finally arrived at the goal which they had been seeking as far as the first problem of design was concerned. The last problem of design, that of apparatus for expeditiously disposing of the water in the pans, was worked out only on paper, owing to the lack of time. No apparatus of this kind has been made up and the writers are only submitting the design as a suggestion that may prove worthy of further consideration by others who take up the work.

CHAPTER V.

Owing to the fact that it was desirable that future sprinkler distribution tests be run in the hydraulic laboratory, a piece of apparatus was designed which required for its working the drainage pit running between the Quimby pump and the pressure tanks in this laboratory.

This apparatus is such that 72 pans will be dumped in one operation. In other words it is really made up of two similar pieces of apparatus, each of which will take care of 72 pans.

The frame work is as shown in the enclosed drawing, made up of tees, angle irons, and stay rods, the whole being covered with No. 16 gauge galvanized iron. The flanges of the tees are so located that they will fit in between two rows of pans which have a clearance of 1-1/2" at the bottom. The part (A Fig. 4) on the drawing is the means by which the pans are kept from sliding off the frame during the dumping opera-

tion. The part marked clamping frame (Fig.5) is also used only during the dumping operation. After the test, this piece of apparatus is laid on top of the pans and fastened securely to the frame by means of the clamping rods (B Fig. 4), and the posts (C Fig.4) so that the pans are held securely to the frame.

Another piece of the apparatus required with this design is the piece shown on the drawings as the "joining strip". It is merely a piece of galvanized iron bent and cut in such a manner as to make a tight connection between the two sets of 72 pans. Fig. 6.

The preferable place for the location of the sprinkler will be at the point directly over the middle of the pit so that at the end of a test each set of pans may be rolled back to its own side of the pit.

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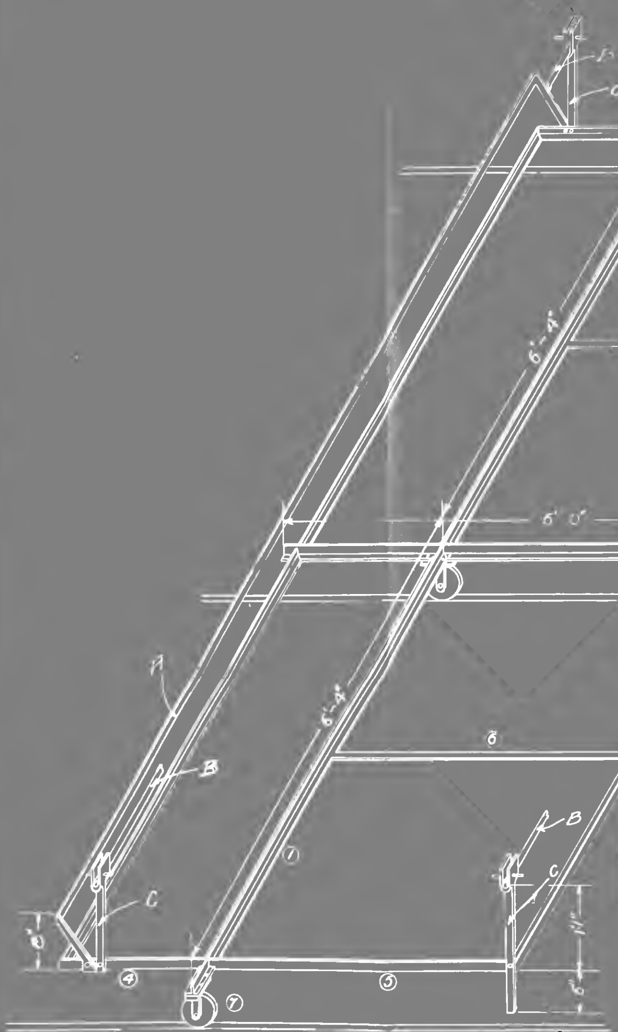
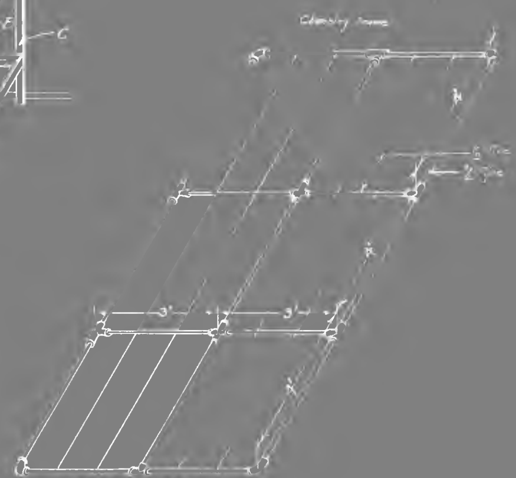


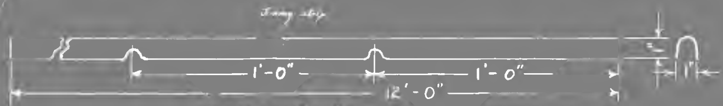
SCALE 1"=1'-0"

Fig. 4



SCALE ½"=1'-0"

Fig. 5



SCALE 3"=1'-0"

Fig. 6

DUMPING APPARATUS

BILL OF MATERIAL

		No.
1	Tees-2"x1½" - 6'4" Long	2
2	Tee - 2"x1½" - 6'-0" "	1
3	Angles-1½"x1¼"x3/16"-5'10½"	4
4	" " " " - 1-10½"	2
5	" " " " - 0-10½"	2
6	Supporting Rods 1"x¼"x5'-10"	2
7	Wheels-as shown	4

All pipes to be cut with a running thread on one end.

MAY 15, 1920

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CHAPTER VI.

Assuming that the sprinkler discharge is completed, the following are the details of the procedure to obtain the amount of discharge per square foot and to get the apparatus ready for the next test.

The "joining strip" is removed and the two sets of pans run back from the pit. By means of the measuring instrument the amount of water in each pan is obtained to .01 of a gallon. After the amount of water in each of the 72 pans has been measured by this means, the clamping frame is fastened securely in place and the set of pans run up on the track to a position where the edge of the inner row of pans will just clear the farther edge of the pit. The wheels (E) are blocked and the outer edge of the frame is raised so that the whole pivots about the three wheels (E) until the frame is practically in an upright position, thus allowing every pan to drain. After the

pans have drained the frame is brought back to its original position, and the clamping frame is removed. Exactly the same procedure is carried out with the other section of pans. Both set of pans are then brought up to the first position and the joining strip put in place.

CHAPTER VII

Although the apparatus as described herein has never been subject to working conditions, the writers feel that the probability of apparatus of this kind proving a success is unquestionable. The main idea of the writers was to keep the apparatus as simple as conditions would allow. They feel that in this apparatus, they have accomplished that which they set out to do, inasmuch as the time of the test will be cut down to at least 1/3 that of former tests and the amount of manual labor necessary has been cut down to a minimum.

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