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A STUDY OF THE YIELD OF THE CAMPUS WELLS

THESIS FOR DEGREE OF B. S.

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1926

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A STUDY OF THE YIELD OF THE CAMPUS WELLS

A THESIS

SUBMITTED TO THE FACULTY OF
THE MICHIGAN STATE COLLEGE OF
AGRICULTURE AND APPLIED SCIENCE

By

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Candidates
for the degree of
Bachelor of Science.

June, 1926.

THESIS

The authors take this opportunity to thank the staff of the Buildings and Grounds Department for their aid and hearty co-operation, and also Professors C. L. Allen and H. C. Woods for their assistance and suggestion.

The purpose of this thesis is to determine the following about the campus wells:

I. The maximum yield,

II. The pressure of air that produces maximum yield,

III. The circle of influence,

IV. Whether the yield is proportional to drawdown,

V. The length of a fire that can be fought using the maximum output of wells in conjunction with one hundred thousand gallon storage reservoir. The number of fire streams are six each delivering two hundred and fifty gallons per minute.

A STUDY OF THE YIELD OF THE CAMPUS WELLS.

At the present time the water supply for Michigan State College is obtained from a sub-artesian well by an electrically driven triple action pump. In addition to this there are two air lift wells that can be operated. Tests were made on these two wells. In the near future a well regulated and efficient system of air lift wells will be installed.

All of the wells here are of sub-artesian character and tap the sand stones of the Coal measures.

Figure II is a geologic section of one of the college wells plotted from a log borrowed from the Geology Department. The location of this well is not known for there was no information regarding its position. However, the date indicated that it was drilled in 1881. At one time these wells were truly artesian in character, but due, perhaps, to the large consumption of the city of Lansing from the same strata, the static water level has been diminished so that it now stands about 818.0 ft. above sea level.

The structural features of the artesian basin, which these wells tap, resemble a stack of saucers placed concave upward. These artesian conditions are purely local in character. East Lansing is well located with regard to these geologic features and is, thereby, in a position to avail itself of the advantages offered by it. The outcrops of the different strata are shown in Figure I. Something of the character of the Coal Measures may be gleaned from that which follows: "A 20 in. well was drilled in 1917 by A. R. Purcell of Jackson for the Lansing Water Works." The samples taken from the borings of this well indicated that the sandstone in the Coal Measures above the salt horizon is too fine grained and closely cemented to yield water freely. The sandstones in the Coal Measures vary so greatly in texture and porosity that perhaps with careful exploration and preservation of samples more freely water-gearing areas could be found in or about the city. Saline waters are encountered below the Coal Measure horizon. The cementing material of the sandstone of this strata contains iron carbonate which upon exposure to weather is oxidysed to limonite. This, evidently, is the reason why bath room fixtures and other hydraulic apparatus in and about East Lansing show rusty blemishes upon them.

The tests that were made dealt with four wells which you will find on the map in the pocket of this book, indicated as 1, 2, 3, and 4. Wells 2 and 4 are connected so that they can be operated.

By plumbing it was found that the depth of Well No. 1 is 336' and that Well No. 3 is 298'. The others could not be plumbed. The casings of these wells are driven to rock. That means that casing depth is about 80' as that is about the depth of the glacial draft here.

As the static water level was measured before each test, it was discovered that they varied as much as two feet on consecutive tests. The reason for this fluctuation may be due to interference from the well in operation behind the Forestry Building, thermometric or barometric conditions and rainfall.

El. of casing	Well No. 1	834.14
El. of casing	Well No. 3	835.03
El. of discharge pipe	Well No. 2	846.53

The following pages will deal with the details, the method of procedure, the data and the apparatus of the test.

In the pocket of this book which is attached to the back cover, you will find a map showing the location and number of the wells which this test deals with. Wells 1, 2, and 3 are located nearly on a straight line and spaced 200 ft. apart. Considerable difficulty was encountered to locate Well 3, because it was not accurately located on the maps. The elevation of the static water level was determined by plumbing wells 1 and 3. As the static water level of well 1 and 3 were the same, the authors assumed that the static water level of well No. 2 was also the same as it lies between Wells No. 1 and No. 3. In order to measure the static water level in Well 2, it would be necessary to uncouple the casing for each run. This would be a difficult task.

The equipment used in this test was an air compressor, wier box, air gage, flow meter, and hook gauge.

The air gauge and flowmeter were tapped into the air line a few feet from the well. The weir box was placed beneath the discharge pipe connected to the air separator tank. The weir used was a 90° triangular weir. All the water pumped was wasted.

In order to determine the drawdown in well No. 2, the well in operation, it was necessary to determine the distance to the footpiece. This was completed by formula and then checked by measurement. At the beginning of each test the pressure necessary to start the well flowing was recorded. This pressure was used in the formula p = wh, in which p is the pressure, h is the height of water column that p will support, and w a constant equal to .433. The measured distance was 268'. By formula the distance is

$$\frac{p}{w} + 28.2 \qquad \text{or} \qquad \frac{104}{.433} + 28.2 = 268.2 \text{ ft.}$$

28.2' is the distance from the discharge pipe which leads to the air separator tank to the static water level.

At intervals of fifteen minutes records were made of the air pressure, inches of water in U tube of flow-meter and the hook gauge elevation. At the end of each test the shut in pressure was recorded and the draw-down in wells 1 and 2 noted.

The shut in pressure is the back pressure of the water column in the well. This is obtained by closing the shut-off valve leading to the air compressor and then reading the air gauge. The shut in pressure is the means by which the draw down in well No. 2 may be obtained. The draw down distance to the foot piece minus the shut in pressure divided by .433 minus the distance to the static water level. You will find the drawdown for each test on pages of this thesis. The drawdown in wells 1 and 3 was found by dropping a plumb line inside the casing.

The circle of influence was plotted from the drawdowns obtained as above. We found the circle of influence to be 600 ft. in diameter.

Well No. 2, only, was operated in the first part of the test due to the failure of the air compressor to build up pressure enough to lift two wells, but after some delay a seventy five horse power electric motor was installed that could develop enough pressure to operate both wells.

To determine the amount of free air used to obtain a gallon of water, study Fig. 5 and Curve for Determining Volume of Free Air. (A blue print found in the back cover of this book). The original of this blue pring, the calibration and description of the flow-meter can be found in Thesis No. 1, 1925, completed by Messrs. M. E. Snider and J. M. Biery.

Figure No. 4 shows a cut of the foot piece used in Wells No. 2 and 4. These were designed and made by Mr. Walter Coss who is employed by the college.

LOG OF TEST RUN ON WELL NO. 2.

April 30, 1926.

Time	Air Gauge Pressure	Flowmeter Left	Flowmeter Right	Hook Gauge
2:15	103 (starting)	4.6	6.7	Initial
2:30	75 Operating	5.05	6.15	1.820
3:00	75	5.05	6.15	1.822
3:15	75	5.10	6.25	1.820
3:30	75	5.10	6.25	1.830
3:45	75	5.10	6.25	1.830
4:00	75	5.10	6.25	1.820
4:20	75	5.15	6.30	1.820

Static Water Level in Well No. 1 from top of casing 15.5'

Starting Pressure 103#

Shut in Pressure 60#

Water Level in Well No. 1 after pumping, from top of casing 19.5'.

LOG OF TEST RUN ON WELL NO. 2.

May 14, 1926.

Time	Air Gauge Pressure	Flowmeter Left	Flowmeter Right	Hook Gauge
2:00	105 (Starting)	----	----	1.439 Initial
2:15	102 Operating	3.45	8.15	1.902
2:30	107	3.90	7.7	1.897
2:45	98	4.0	7.7	1.896
3:00	103	3.7	8.0	1.895
3:15	108	3.5	8.2	1.895
3:30	110	3.4	8.25	1.895
3:45	112	3.5	8.2	1.895

Stopped Running at 3:45 due to blow-off valve failing to hold.

Shut in Pressure 60#

Static Water Level in Well No. 1 - 18.75'

Static Water Level in Well No. 3 - 18.00'

Water Level after Pumping, in No. 1 23.9'

Water Level after Pumping, in No. 3 24.3'

LOG OF TEST RUN ON WELL NO. 2

May 17, 1926.

Time	Air Gauge Pressure	Flowmeter Left	Flowmeter Right	Hook Gauge
1:45	104 (Starting)	----	----	1.434 Initial
2:00	103 Operating	3.7	7.8	1.903
2:15	103	3.8	7.7	1.897
3:00	103	3.8	7.7	1.893

Belt Broke so we ceased pumping.

Shut in Pressure - 65#.

Static Water Level Well No. 1 - 15.75'

Static Water Level Well No. 3 - 16.3'

Water Level, after Pumping, Well No. 1 - 20.5'

Water Level, after Pumping, Well No. 3 - 22.75'

LOG OF TEST RUN IN WELLS [illegible] and 4.

May 18, 1926.

Time	Air Gauge Pressure	Flowmeter Left	Flowmeter Right	Hook Gauge
1:30	105 (Starting)	----	----	1.430 Initial
2:00	92 Operating	4.45	7.1	1.897
2:15	90	4.45	7.1	1.892
2:30	89	4.50	7.0	1.892
2:45	88	4.60	6.9	1.881
3:00	87	4.60	6.9	1.882

Pressure lowered and run continued.

Time	Air Gauge Pressure	Flowmeter Left	Flowmeter Right	Hook Gauge
3:15	82	4.8	6.7	1.876
3:30	83	4.8	6.7	1.878
3:45	84	4.75	6.75	1.876
4:00	84	4.75	6.75	1.877
4:15	84	4.8	6.7	1.876
4:30	83	4.8	6.7	1.874
4:45	84	4.8	6.7	1.874

Shut in Pressure 63#

Static Water Level Well No. 1 - 16.2'

Static Water Level Well No. 3 - 17.0'

Water Level after Pumping, No. 1 - 31.75'

Water Level after Pumping, No. 3 - 36.0'

RESULTS.

April 30, 1926.

Pressure	Head on Weir	Q cu.ft. per sec.	Gals. per Min.	Inches of H_2O Flowmeter	Vol.of Comp. air from Chart	Vol. of free Air	Vol. of free air per gal. Cu.ft.
75	.442	.329	147.5	1.05	25	152	1.03
75	.444	.333	149.5	.55	17	104	.695
75	.442	.329	147.5	.55	17	104	.705
75	.452	.345	154.7	.575	18	110	.711
,75	.452	.345	154.7	.575	18	110	.711
75	.442	.329	147.5	.575	18	110	.711
75	.442	.329	147.5	.575	18	110	.711

Drawdown $= 268 - \frac{60}{.433} - 27.9 = 268 - 138.5 - 27.9 = 101.6$

May 14, 1926.

102	.463	.370	166.0	2.35	41	325	1.955
107	.458	.359	161.0	1.9	36	297	1.845
98	.457	.356	159.7	1.85	35	268	1.675
103	.456	.353	158.4	2.15	38	303	1.910
108	.456	.353	158.4	2.35	41	341	2.15
110	.456	.353	158.4	2.45	41	346	2.18
112	.456	.353	158.4	2.55	41	352	2.22

Drawdown $= 268 - \frac{60}{.433} - 30.32 = 268 - 138.5 - 30.3 = 99.2'$

May 17, 1926.

103	.469	.381	171.0	2.05	37	295	1.725
103	.463	.370	166.0	1.95	36	288	1.735
103	.459	.362	162.5	1.95	36	288	1.770

Drawdown ; $268 - \frac{65}{.433} - 28.0 = 268 - 150 - 28 = 90'$

RESULTS

May 18, 1926.

Pressure	Head on Weir	Q cu.ft. per sec.	Gals. per Min.	Inches of H_2O Flowmeter	Vol. of Comp. air from Chart	Vol. of free Air	Vol. of free air per gal. Cu. ft.
92	.467	.377	169	1.33	28.5	208	1.23
90	.462	.367	165	1.33	28.5	203	1.23
89	.462	.367	165	1.25	27.5	194	1.18
88	.451	.346	155	1.15	27.5	191	1.23
87	.452	.346	155	1.15	27.5	189	1.22

Changed Pressure.

82	.446	.336	151	0.95	23.5	150	.994
83	.448	.340	153	0.95	23.5	157	1.03
84	.446	.336	151	1.0	24.0	161	1.065
84	.447	.338	152	1.0	24.0	161	1.06
84	.446	.336	153	0.95	23.5	158	1.03
83	.444	.332	149	0.95	23.5	157	1.05
84	.444	.332	149	0.95	23.5	158	1.06

Drawdown $= 268 - \frac{63}{.433} - 28.5 = 268 - 145 - 285 = 94.5$

CONCLUSIONS.

Tests have been made as to the quantity of water that the mains will furnish, using pressures of 75# to 80#, and it was found that the East Lansing Fire Engine using two streams and 175# pressure lowered the pressure in the main to 25#. Therefore, it is possible to assume that by raising the main pressure more streams can be taken from the main. The present East Lansing fire engine is equipped to handle three fire streams each delivering 250 gallons per minute. Using the East Lansing engine, rated 750 gallons per minute, the duration of fire that can be fought is as follows, - using maximum output of wells plus 100,000 gallons storage.

Using 3 streams 250 gallons per minute = 750 gal. per min.

maximum capacity of wells = 300 gal.

Storage 100,000 gallons.

750 - 300 = 450 drawn from storage per min.

$\frac{100,000}{450}$ = 222 minutes or 3 hours and 42 minutes.

Using 6 streams at 250 gallons per minute = 1500 gal. per min.

100,000 gal. storage.

1500 - 300 = 1200 gal. used from storage.

$\frac{100,000}{1200}$ = 83½ minutes, or 1 hour, 23 minutes.

Using 6 streams at 250 gallons each = 1500 gal. per min.

200,000 gal. storage.

1500 - 300 = 1200 gal. per min. used from storage.

$\frac{200,000}{1200}$ = 167 min. or 2 hours, 47 minutes.

The best pressure to operate the wells is about 75#; just enough to keep wells flowing. The volume of free air in cubic feet per gallon of water raise is .695 , using 75# air pressure. If the pressure is permitted to fall below 68# the well will cease to flow and if pressure is raised above 75#, the volume of free air per gallon of water becomes excessive and is uneconomical.

1. The maximum combined capacity of wells No. 2 and 4 is about 300 gallons per minute.
2. The pressure produces maximum yield of 105 pounds.
3. Find chart for circle of influence in pocket of this book.
4. The results indicate that pressures above 85 pounds produce an uneconomical drawdown, assuming that the yield varies directly as the drawdown.

The submergence of the footpiece is about 52' which agrees with the figures quoted by the Sullivan Machinery Company for wells having a lift from 100' to 200'. The lift of this well is about 140'.

The results clearly indicate that something is wrong. Perhaps the footpiece needs cleaning or renewing. The air compressor should give a wider range of pressures.

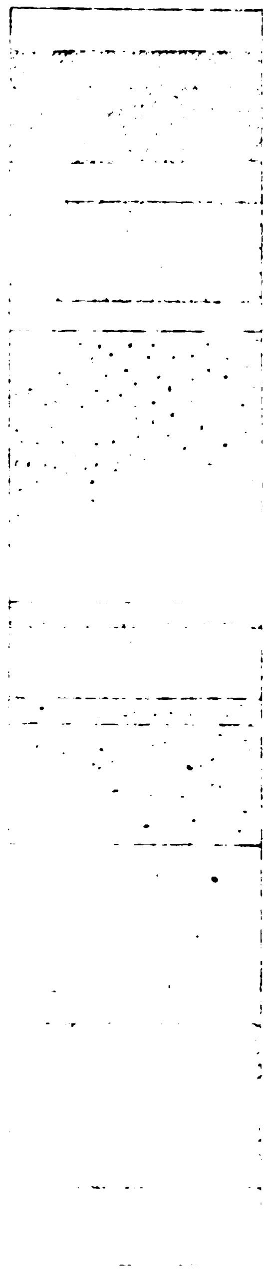
The action of the well when operating is poor. The water does not flow steadily but it comes up with slugs of air. The flow surges a good deal. A good air lift well flows steadily with quiet purr.

Fig. 1

LAKE HURON
LAKE MICHIGAN
Dundee Limestone
Traverse formation
Antrim Shale
Coldwater Shale
Marshall Shale
Grand Rapids Series
Coal measure
SAGINAW BAY
Lansing
Marshall Shale
Coldwater shale
Antrim shale
Dundee Limestone
Upper Monroe dolomite
Sylvania
Sandstone
Lower Monroe dolomite
LAKE ST CLAIR
LAKE ERIE
Antrim Shale

Fig. 2

Depth — Description of Strata



10 20' — Clay

Dark clay and sand

Dark blue-black clay with bits of coal

No record

Light colored, clayey paste, some "silky"

No record

Light colored sandstone { Course, depth 140' / Fine, " 150'

Sandy clay (scrub slate) with dark carbonaceous bits

Sandstone nearly white and 5% 10% bits of carbonaceous material

Course sandstone (white) speckled with coal

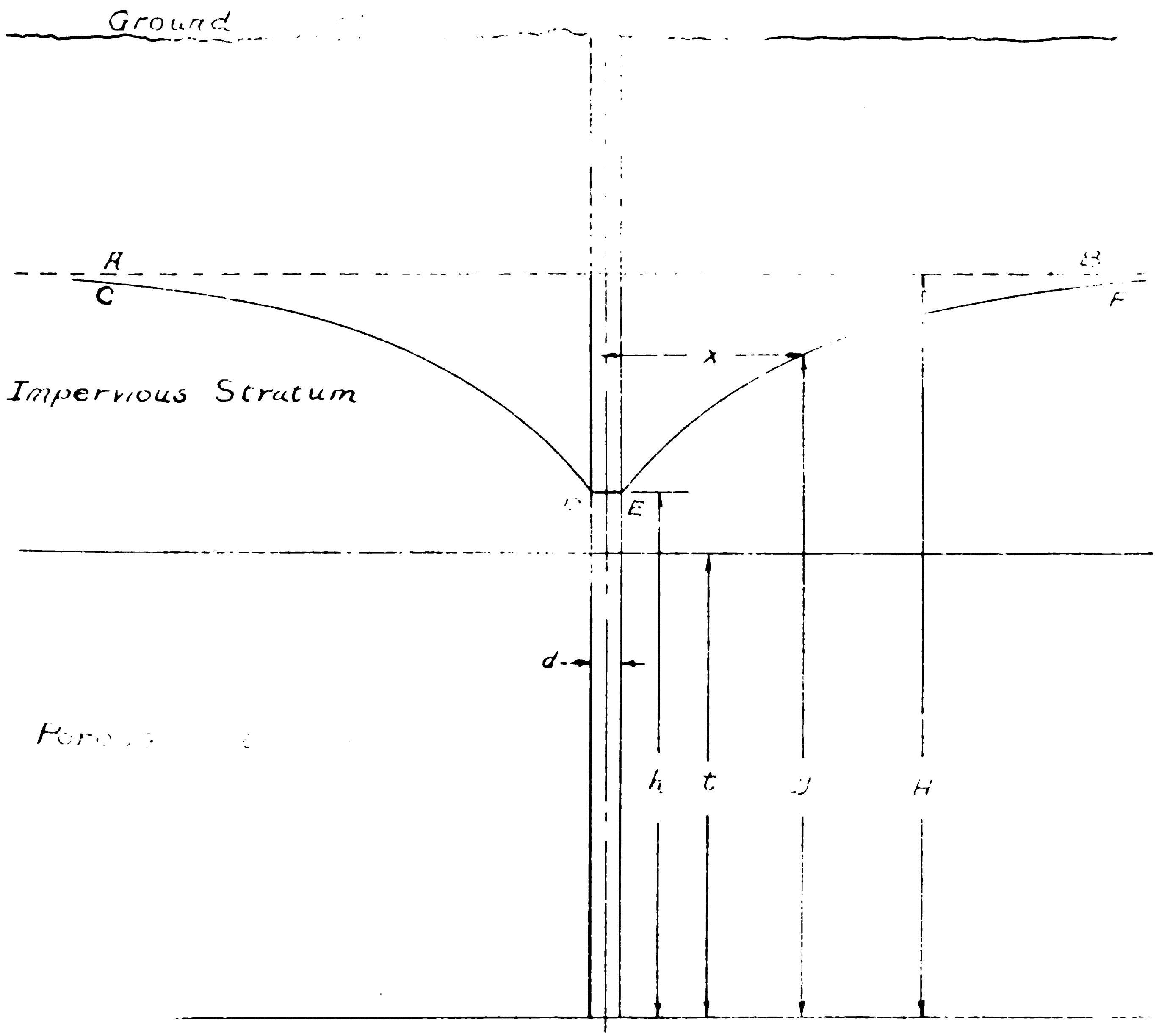
Fine white sandstone with iron (rust) and black specks

White sand with black (coal) specks

[illegible] clay

Fine [illegible]

3



...igonal pressure-head at the bottom of the stratum;

Thickness of porous stratum;

h = Head at bottom of well when flowing;

d = Diameter of well;

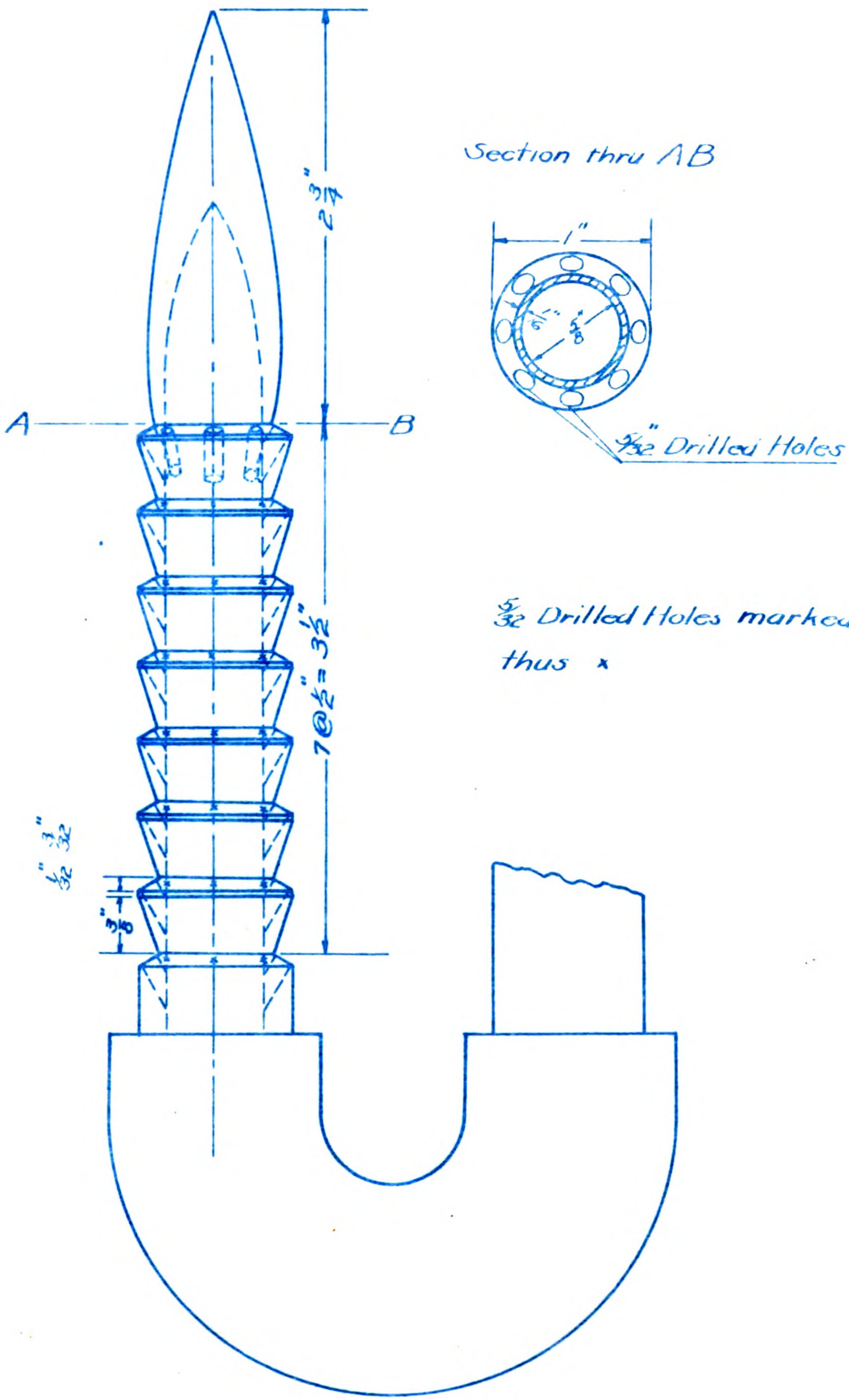
R = Radius of circle of influence;

r = Radius of well;

x & y = co-ordinates of any point on curve CD - EF;

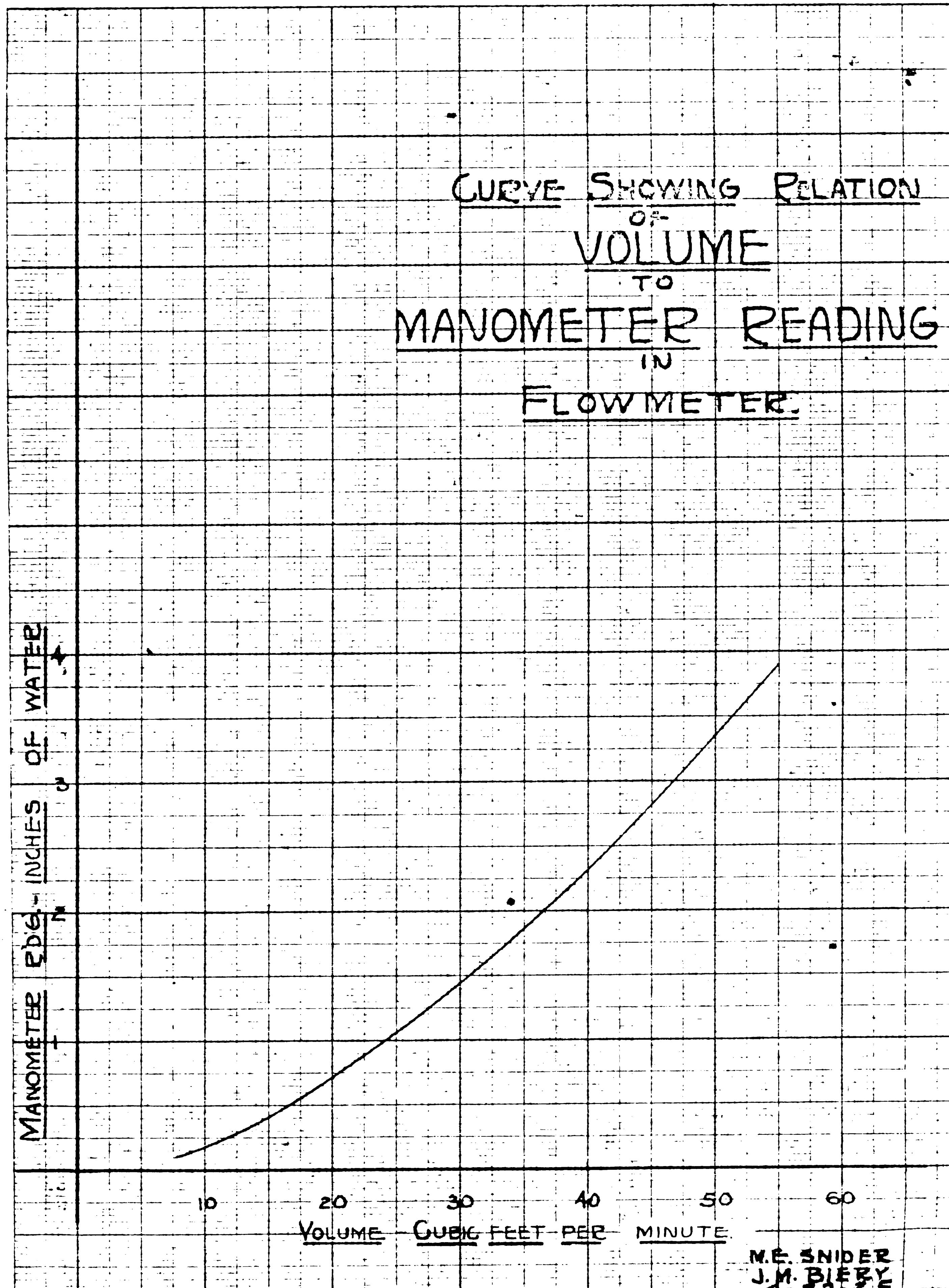
J. Peterson
J. Dawson

Fig 4



Section thru AB
1"
5/8"
5/32" Drilled Holes
A
B
2 3/4"
7@1/2" = 3 1/2"
1/32"
3/32"
3/8"
5/32 Drilled Holes marked thus x

fig. 5


CURVE SHOWING RELATION
OF
VOLUME
TO
MANOMETER READING
IN
FLOWMETER
MANOMETER RDG. - INCHES OF WATER
1
2
3
4
10
20
30
40
50
60
VOLUME CUBIC FEET PER MINUTE
M.E. SNIDER
J.M. BIERY

Pocket
as:
o Suppls
&
4 Fig