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CALIBRATION CONSTANT OF THE WRIGHT FIELD FIVE-FOOT WIND TUNNEL

Air Service Information Circular, Volume VII, No. 643

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WASHINGTON : 1930

CALIBRATION CONSTANT OF WRIGHT FIELD FIVE-FOOT WIND TUNNEL

Prepared by D. M. Borden, Matériel Division, Wright Field, Dayton, Ohio, March 19, 1929

OBJECT

The 5-foot wind tunnel at McCook Field was dismantled during February, 1928, and moved to the new Wright Field. The new set-up was completed in February, 1929. The differences between the set-up at Wright Field and the set-up at McCook Field are shown by Figures 2 to 14, inclusive, in this report. Figures 2 to 6, inclusive, show the tunnel at McCook Field, while Figures 7 to 13, inclusive, and Figure 14 show the tunnel at Wright Field. It will be noted that the main difference is the addition of a larger experimental cabin at Wright Field. This cabin is 17 feet wide as compared to 10.5 feet at McCook Field. The building at McCook Field was 14 by 66 by 160 feet with the tunnel 9.75 feet above the floor, while at Wright Field the building is 20 by 66 by 200 feet with the tunnel 9.75 feet above the floor.

Due to the fact that the tunnel had been completely dismantled and moved to a larger building and the large experimental cabin added, it was thought necessary to check the old calibration made at McCook Field.

METHOD OF TEST

The building around the tunnel was first traversed with a vane anemometer at two wind tunnel speeds approximately 40 and 190 miles per hour and the flow adjusted by means of a door back of the tunnel (see fig. 14) until an equal amount of air was returning on each side of the tunnel.

The traverses of the tunnel proper were then made with a ¼-inch pitot-static tube, readings being taken at 1-inch intervals. Four traverses at two speeds, 1.1 inch alcohol and 9-inch alcohol, were made along the horizontal and vertical diameters of the tunnel in two planes, 13½ inches ahead of the plane of the N. P. L. balance and 95 inches ahead of the plane of the N. P. L. balance. During these traverses, the static pressure on the 8-unit static plates were held constant at the indicated pressures of 1.1 and 9.0 inches of alcohol. These static plates are 126 inches ahead of the plane N. P. L. balance and just at the beginning of the straight section of the tunnel. The difference in pressure recorded by the pitot side of the pitot-static tube and the atmospheric pressure was read on an inclined Krell manometer of 1 : 40 slope for the lower speed and of 1 : 20 for the higher speed. The static side of the pitot-static tube was connected differentially (to allow a greater slope to be used) with the 8-unit static plates to an inclined Krell manometer of 1 : 20 slope. From these readings it was possible to determine the actual velocity head and the relation of this head to the 8-unit static plate reading which is used in the actual test work.

The pressures obtained were plotted (figs. 15 to 22, inclusive), and the average pressure heads within a 46-inch circle obtained by planimetering the curves.

RESULTS

The four traverses made in the plane 13½ inches ahead of the plane of the N. P. L. balance showed the velocity head to be 0.997 times the suction recorded by the 8-unit static plates. The traverses made 95 inches ahead of the plane of the N. P. L. balance showed the velocity head to be 0.975 times the suction recorded at the 8-unit static plates. The results obtained 13½ inches ahead of the plane of the N. P. L. balance will be used for the actual test work since the models are always placed in this region of the tunnel.

The following table shows a comparison of the conditions obtained in the tunnel at Wright Field as compared to the tunnel at McCook Field:

	Wright Field		McCook Field
	13½ inches ahead of N. P. L. balance plane	95 inches ahead of N. P. L. balance plane	12 inches ahead of N. P. L. balance plane
	Per cent	*Per cent*	*Per cent*
Velocity fluctuation in time	0.4	0.5	0.4
Variation of velocity from the mean	1.5	2.0	.7

A summary of the results of the various traverses is given in the following table. These values are for a 46-inch circle.

SUMMARY OF RESULTS

Wahlen gage setting	Excess of pitot S. H. over Wahlen gage	Static head	Dynamic head	Velocity head	Calibration factor	Traverse position
1.104 9.025	0.0331 .2270	1.1335 9.2520	0.0381 .3085	1.0954 8.9435	0.995 .991	Horizontal: 13½ inches ahead of plane of N. P. L. balance.
1.100 8.9810	.0379 .2525	1.1379 9.2335	.0331 .2557	1.1048 8.9778	1.004 .999	Vertical: 13½ inches ahead of plane of N. P. L. .balance.
1.100 9.000	.0092 .0555	1.1092 9.0555	.0380 .3030	1.0712 8.7525	.973 .973	Horizontal: 95 inches ahead of plane of N. P. L. balance.
1.097 9.000	.0076 .0423	1.1046 9.0423	.0308 .2910	1.0738 8.7513	.979 .973	Vertical: 95 inches ahead of plane of of N. P. L. balance.

Average calibration factor 13½ inches ahead of N. P. L. balance=0.997.

94022—30——2

DISCUSSION

It is shown in the preceding table that the head as read on the Wahlen gage connected to the 8-unit static plates is 0.997 of the average velocity head in the 46-inch diameter circle. Since it is desirable to have all coefficients obtained from wind-tunnel data based on standard conditions, which may or may not be the existing conditions, the head used for a given standard velocity will be the head corresponding to that velocity under standard conditions. For standard conditions:

$$V=45.13\ \sqrt{h}$$

where

V = velocity, m. p. h.
h = velocity head in inches of water

Since this calibration showed the head indicated on the 8-unit static plates to be 0.997 × velocity head

$$V=45.13\ \sqrt{H\times 0.997}$$
$$=45.10\ \sqrt{H}$$

where

H = head indicated at 8-unit static plates in inches water.

The velocity fluctuation in time is seen to be the same at Wright Field as at McCook Field, but the variation in velocity from the mean is 1.5 per cent as compared to 0.7 per cent at McCook Field. This variation is caused by an energy loss in the center of the tunnel and is greater at Wright Field than at McCook Field due to the addition of two rings and two brass shells, which support the honeycomb core of the straightener. The sketch, Figure 1, shows the condition at Wright Field as compared to the condition at McCook Field. The method of supporting the core at McCook Field was unsatisfactory because the core could not be removed and replaced in exactly the same position each time, which changed the flow alignment. By redesigning the core the variation in velocity from the mean could no doubt be reduced from 1.5 per cent to approximately 0.5 per cent.

It is believed that the variation in velocity is insufficient to prevent reliable results from being obtained in the tunnel, and that a redesign of the core is unjustified.

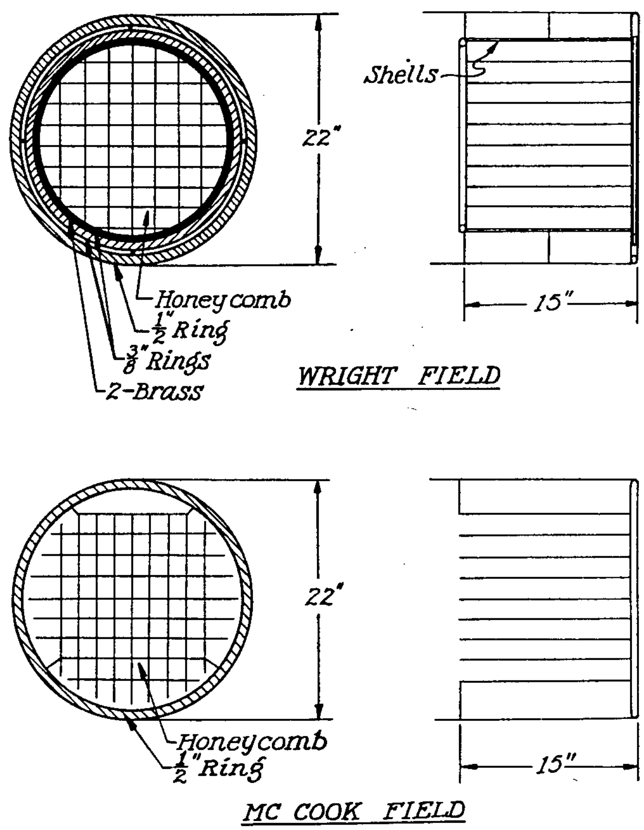


FIGURE 1.--Core for wind tunnel air straightener

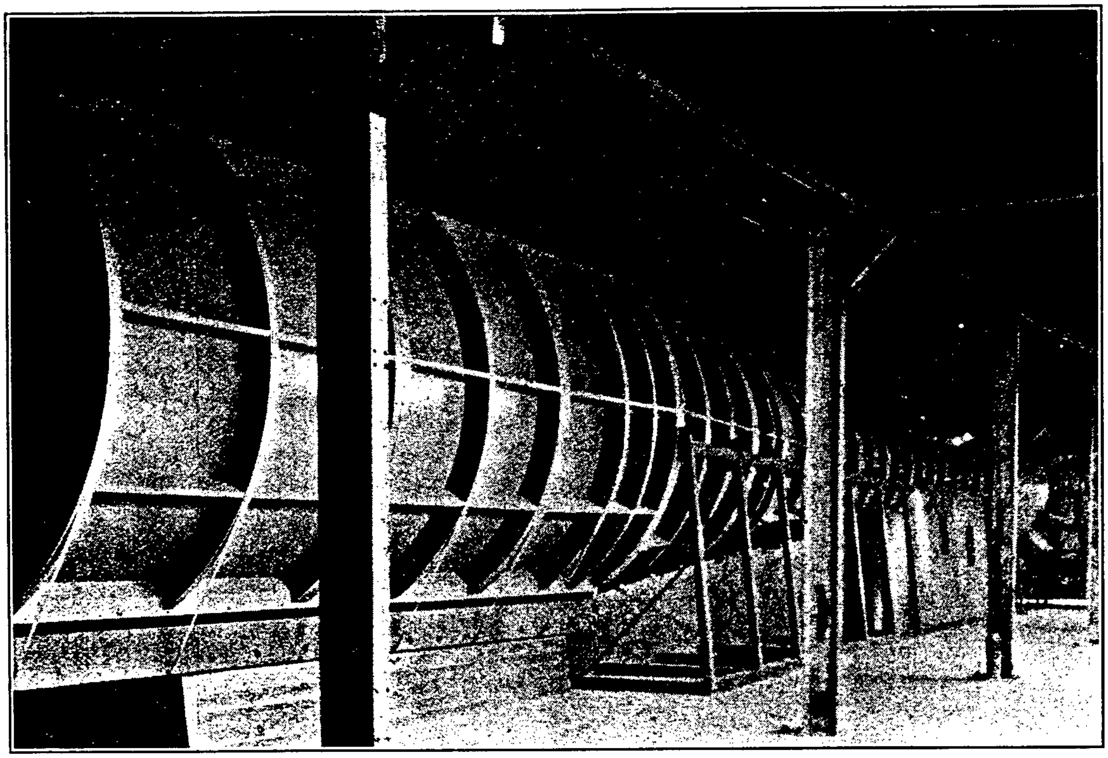


FIGURE 2

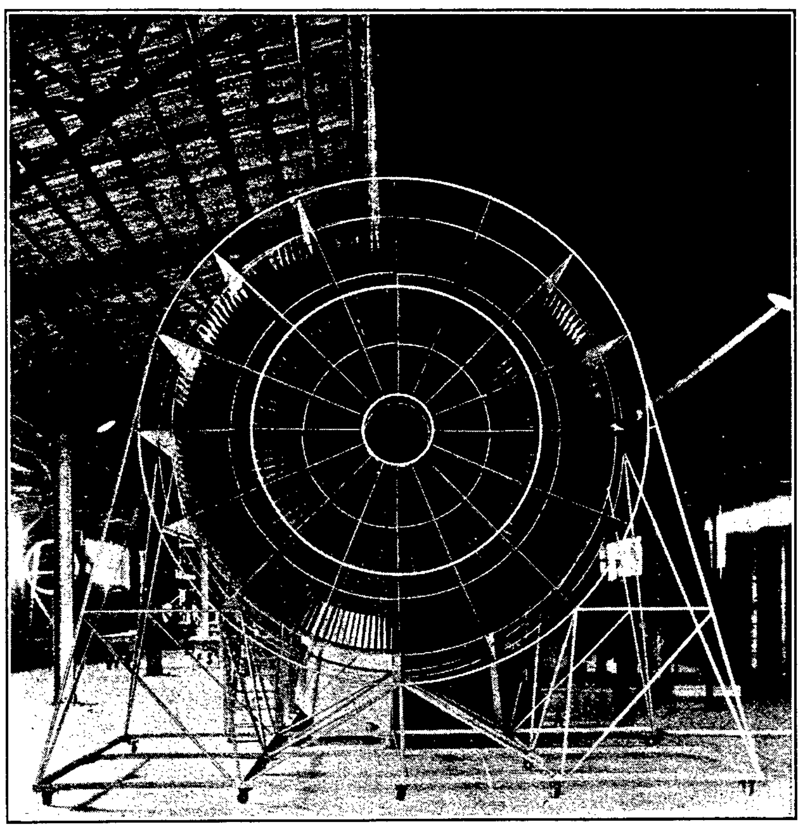


FIGURE 3

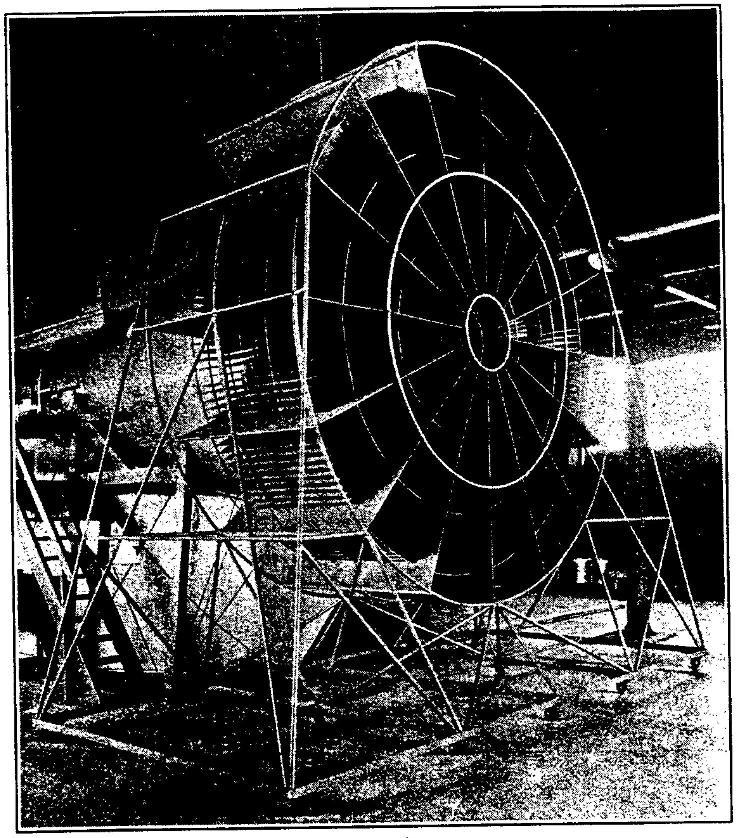


FIGURE 4

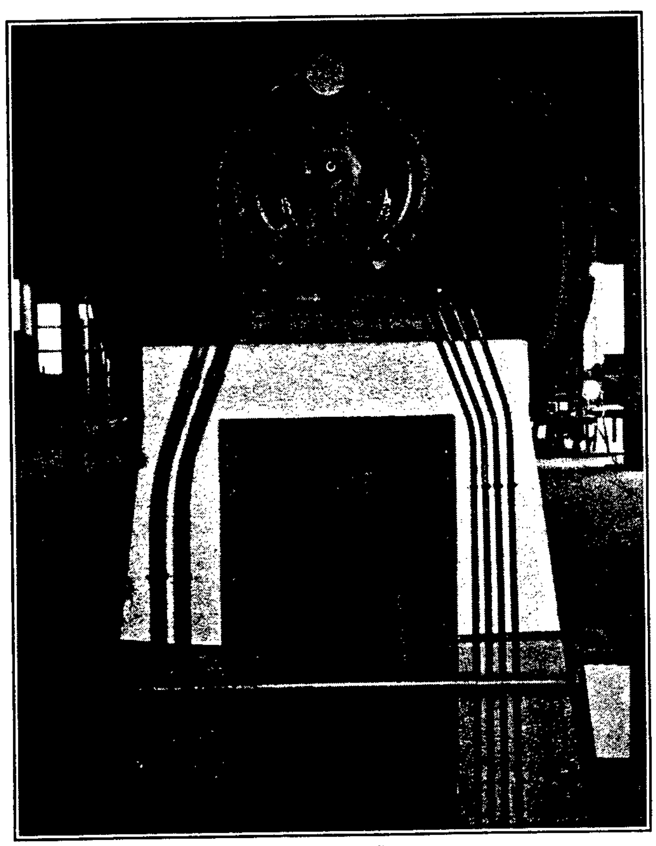


FIGURE 5

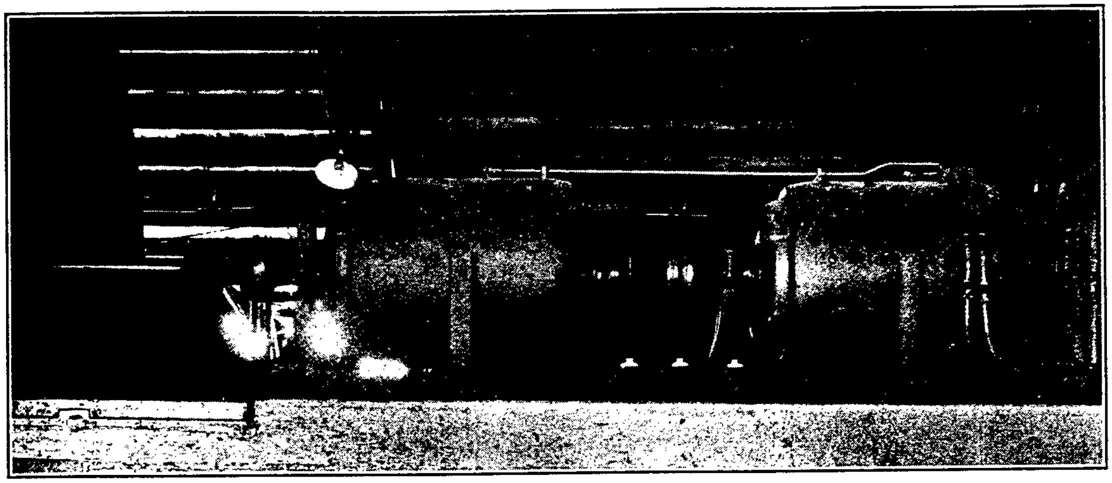


FIGURE 6

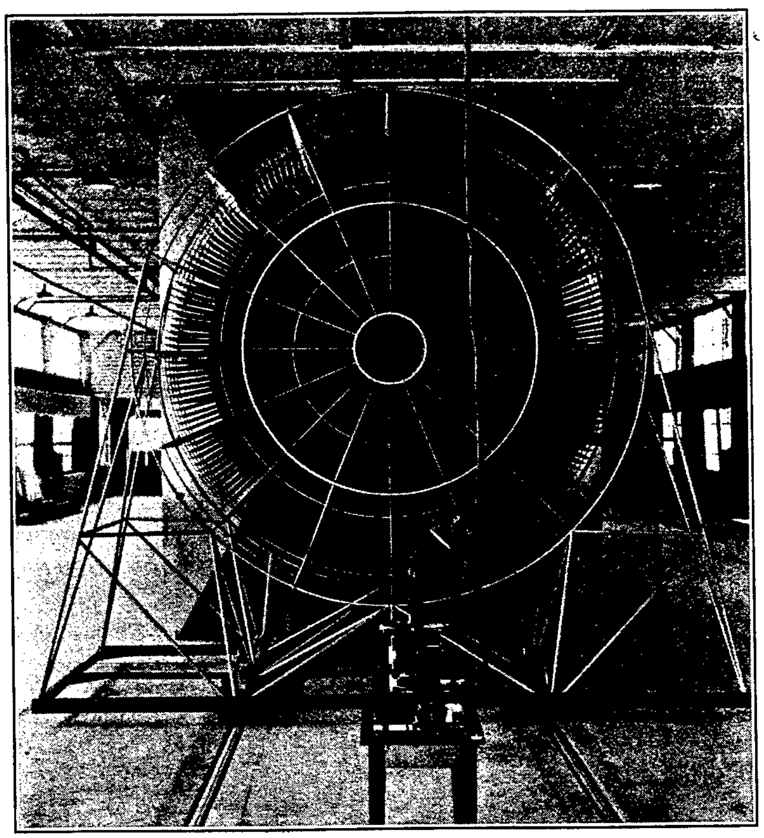


FIGURE 7

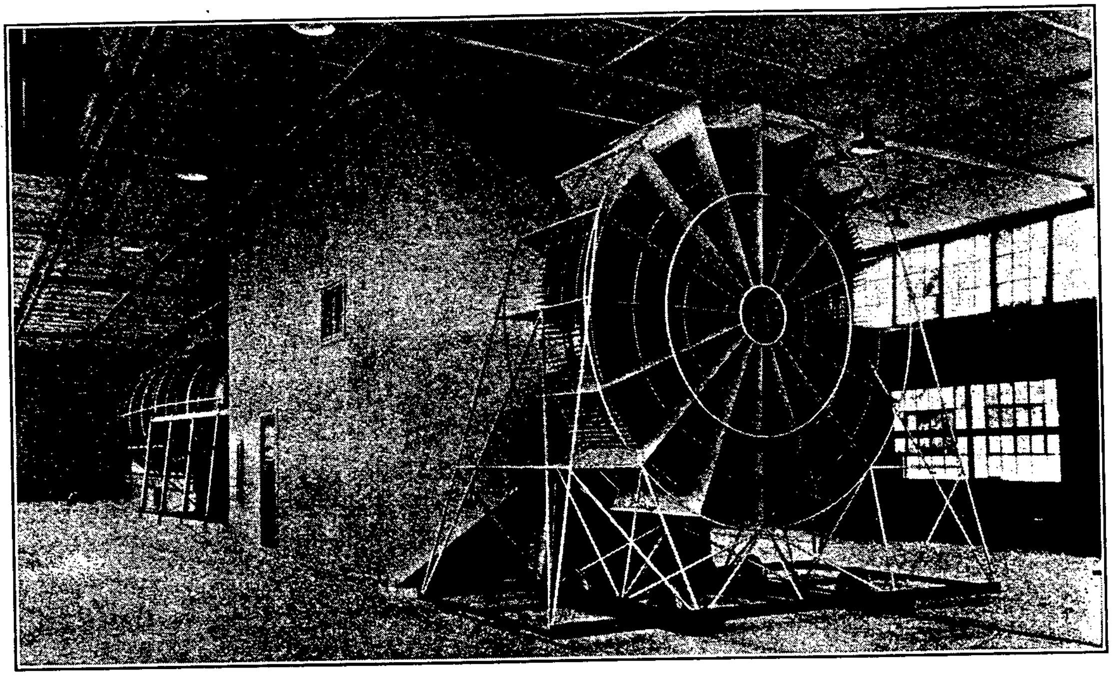


FIGURE 8

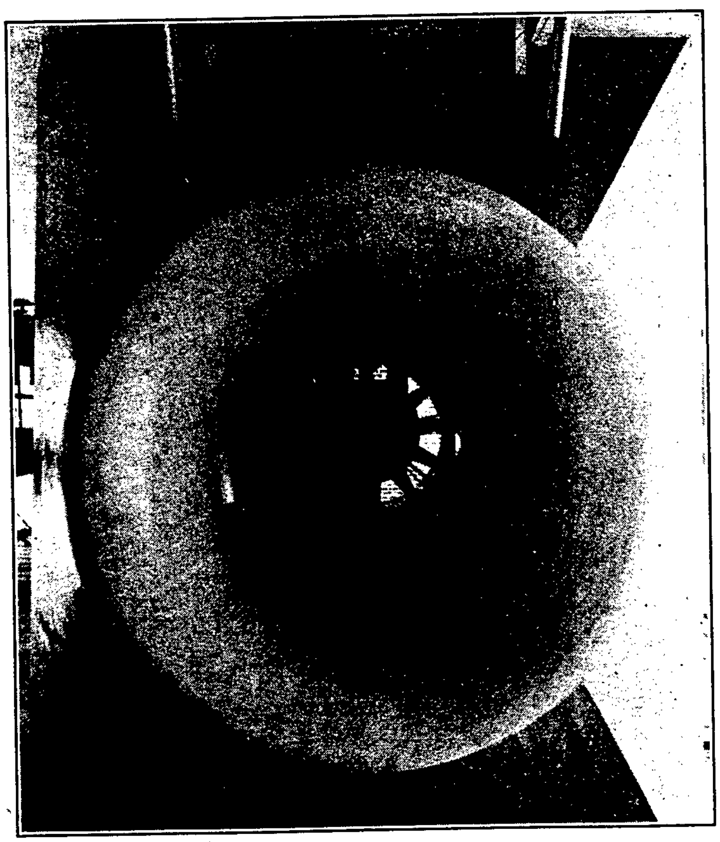


FIGURE 9

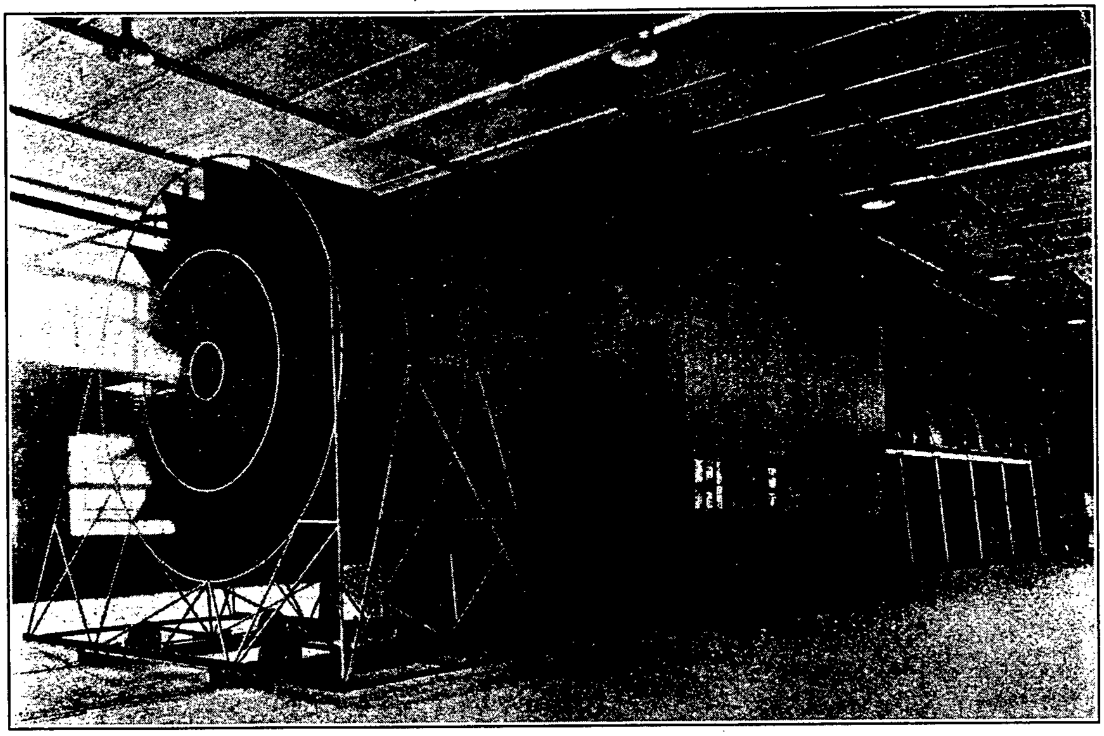


FIGURE 10

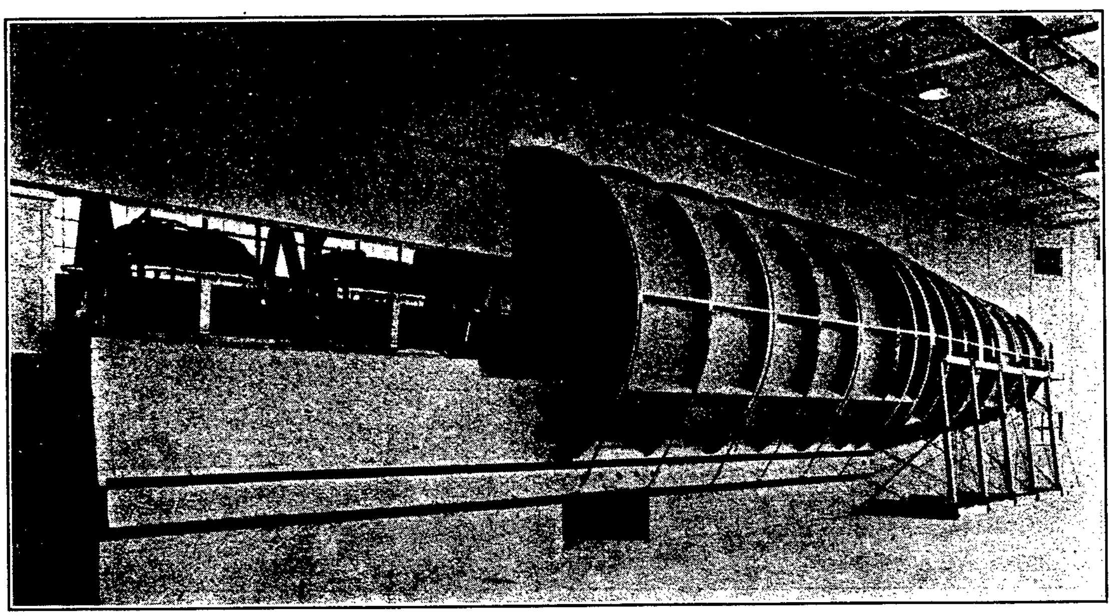


FIGURE 11

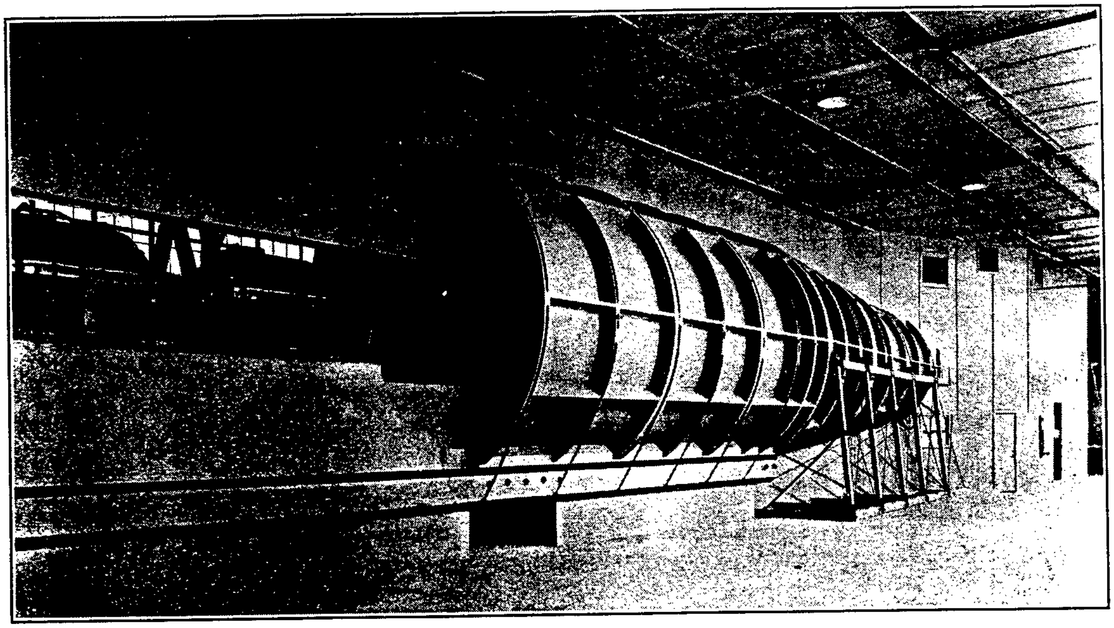


FIGURE 12

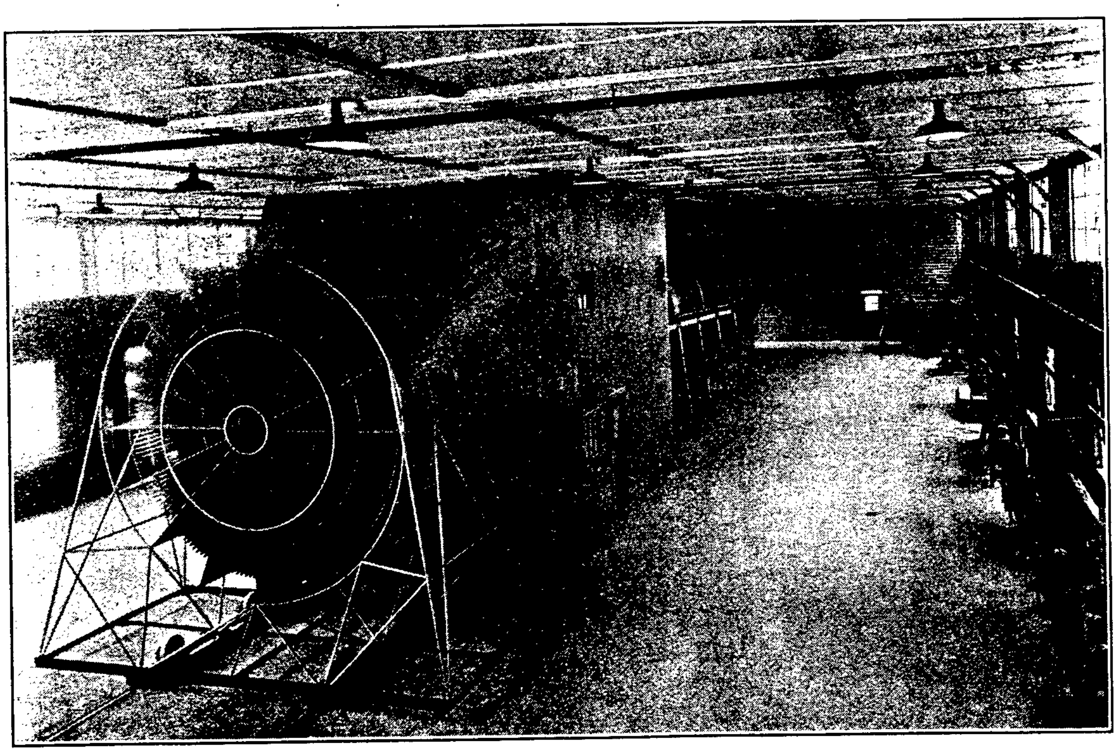


FIGURE 13

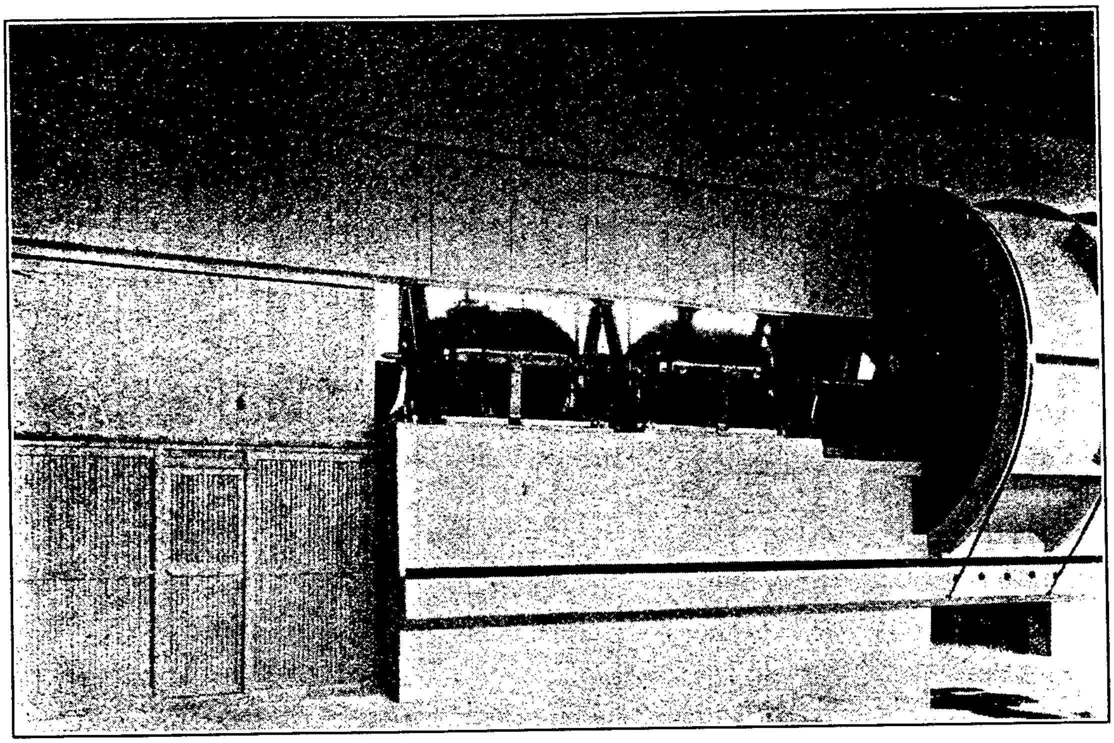


FIGURE 14

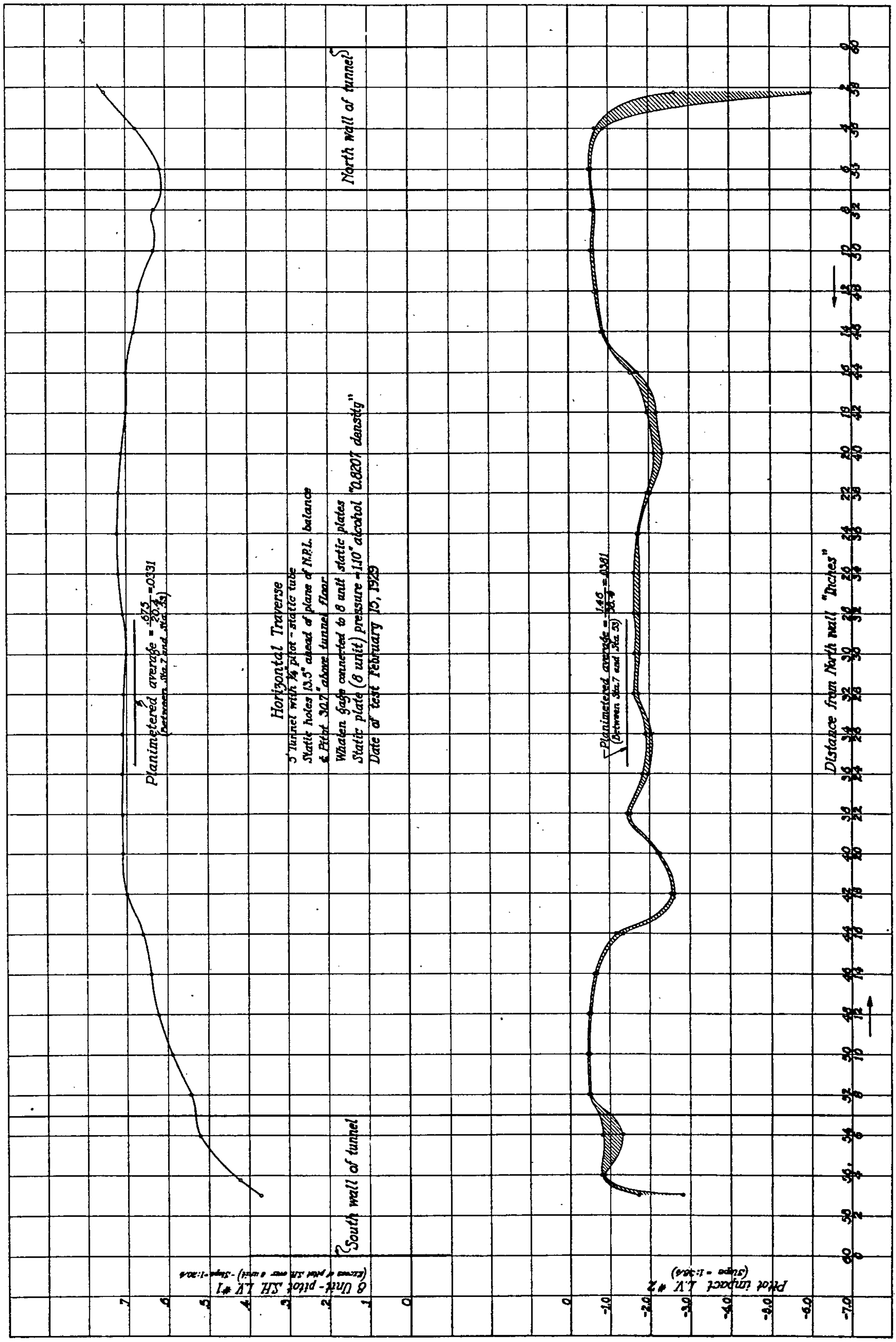

Horizontal Traverse
5' tunnel with ¼" pitot - static tube
Static holes 13.5" ahead of plane of N.P.L. balance
& Pitot 30.7" above tunnel floor
Whalen gage connected to 8 unit static plates
Static plate (8 unit) pressure -1.10" alcohol "0.8207 density"
Date of test February 15, 1929
North wall of tunnel
South wall of tunnel
Distance from North wall "Inches"
Pitot impact LV #2
8 Unit-pitot SH LV #1

FIGURE 15

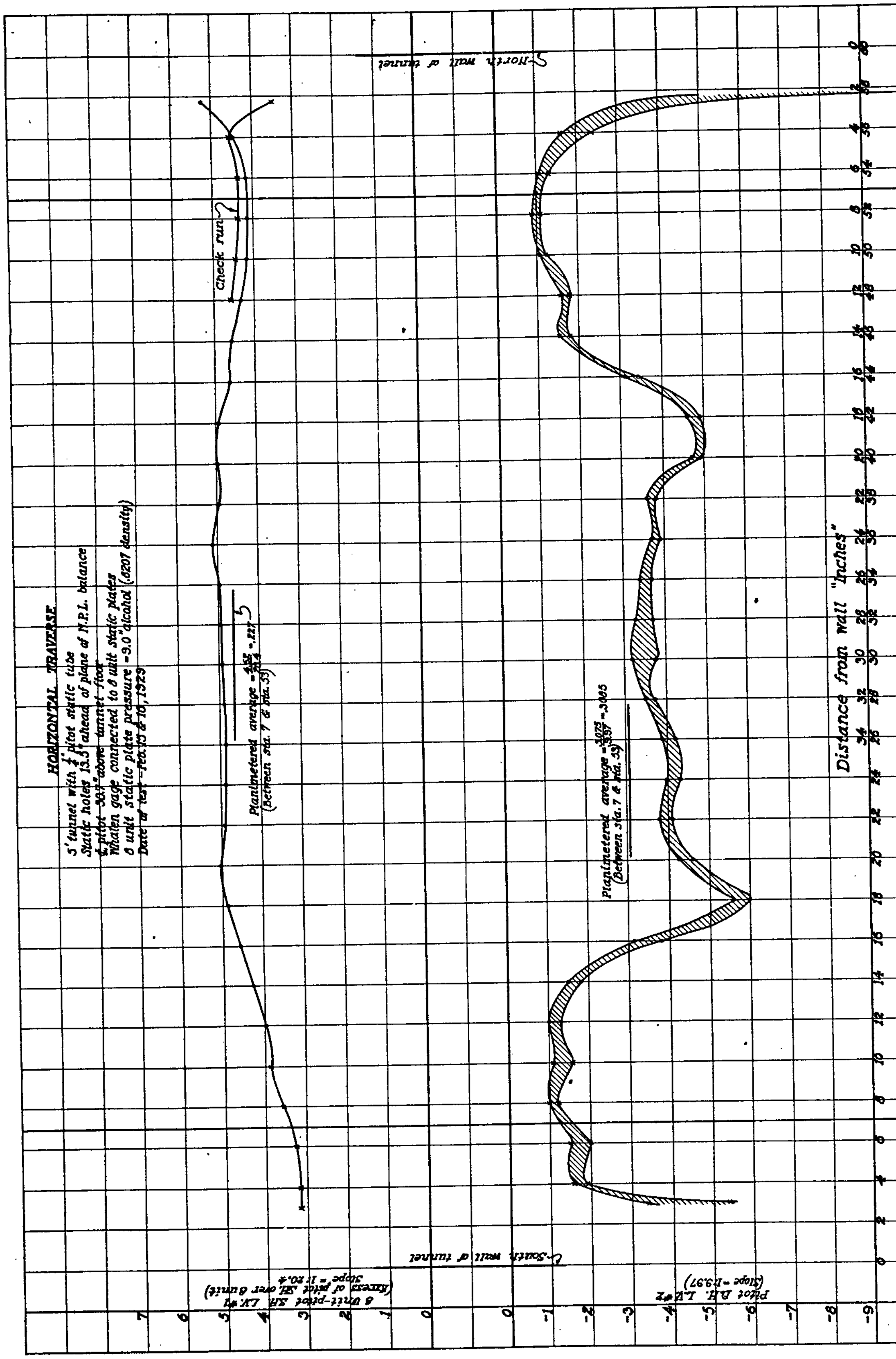

HORIZONTAL TRAVERSE
5' tunnel with 1/4" pitot static tube
Static holes 13.5" ahead of plane of N.P.L. balance
pitot 30.0" above tunnel floor
Whalen gage connected to 8 unit static plates
8 unit static plate pressure -9.0" alcohol (.8207 density)
Date of test - Feb. 15 & 16, 1929
Planimetered average
(Between sta. 7 & sta. 53)
Check run
North wall of tunnel
South wall of tunnel
8 Unit-pitot SH. LV #1
(Excess of pitot SH. over 8 unit)
Pitot DH. LV #2
Distance from wall "Inches"

FIGURE 16

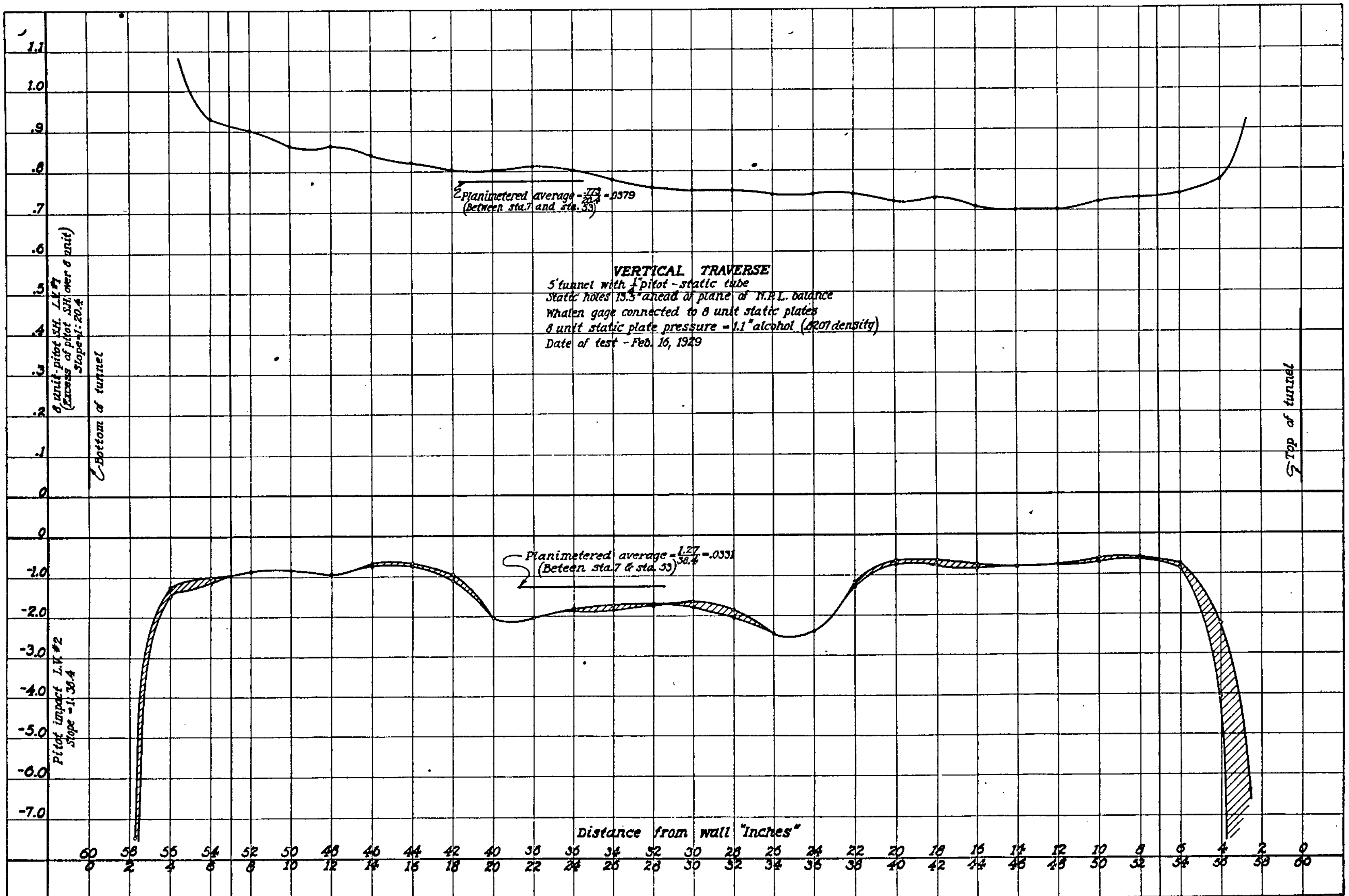

VERTICAL TRAVERSE
5' tunnel with 1/4" pitot-static tube
Static holes 13.5" ahead of plane of N.P.L. balance
Whalen gage connected to 8 unit static plates
8 unit static plate pressure = 1.1" alcohol (.8207 density)
Date of test - Feb. 16, 1929
Planimetered average = .773/20.4 = .0379
(Between sta. 7 and sta. 33)
Planimetered average = 1.27/38.4 = .0331
(Beteen sta. 7 & sta. 33)
8 unit-pitot S.H. L.V. #1
(Excess of pitot S.H. over 8 unit)
Slope = 1:20.4
Pitot impact L.V. #2
Slope = 1:38.4
Bottom of tunnel
Top of tunnel
Distance from wall "Inches"

FIGURE 17

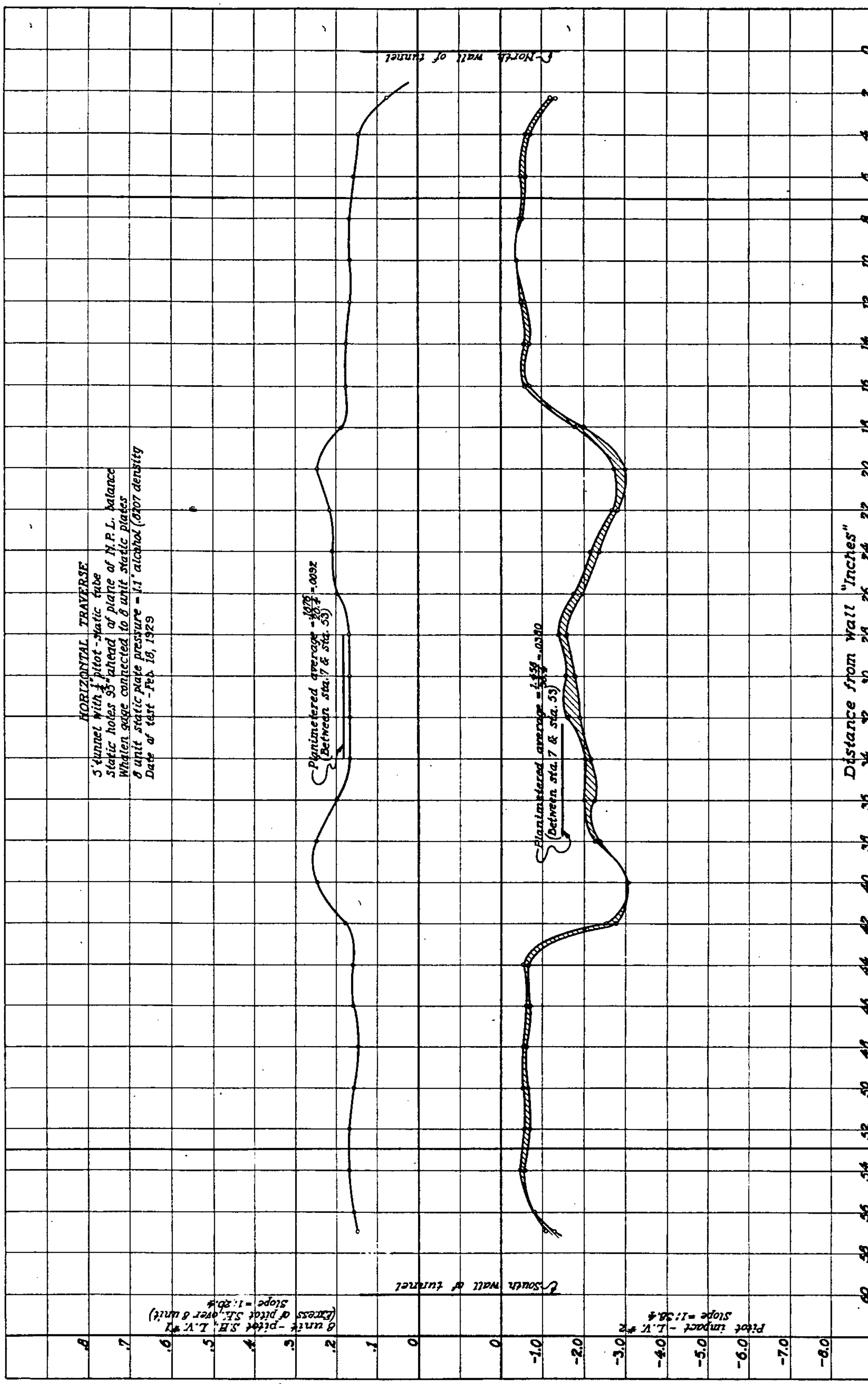
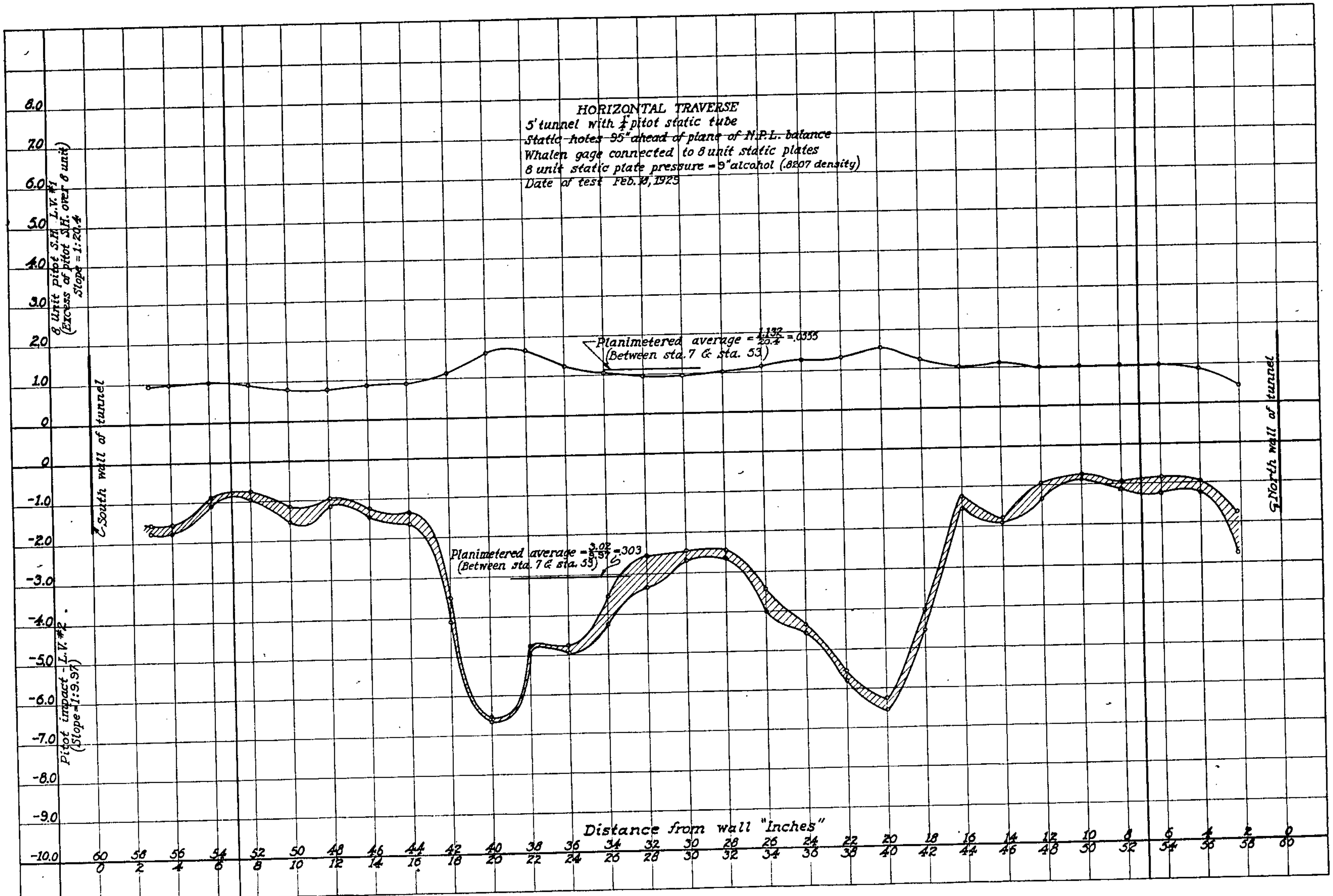
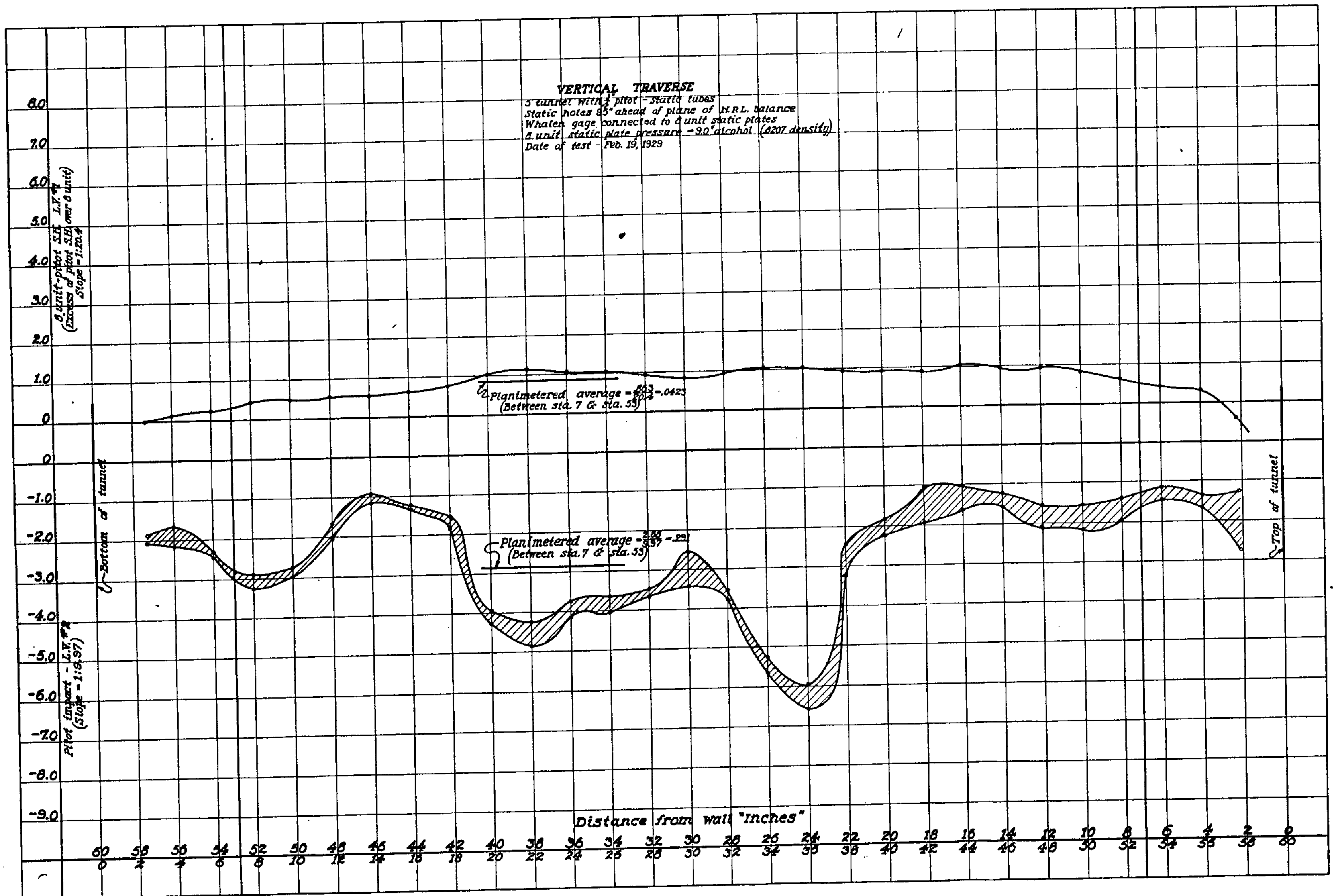

HORIZONTAL TRAVERSE
Distance from Wall "Inches"
North wall of tunnel
South wall of tunnel
Pitot impact - L.V. #2
Slope = 1:58.4

FIGURE 19



HORIZONTAL TRAVERSE
5' tunnel with 1/4" pitot static tube
Static holes 95" ahead of plane of N.P.L. balance
Whalen gage connected to 8 unit static plates
8 unit static plate pressure = 9" alcohol (.8207 density)
Date of test Feb. 10, 1923
Planimetered average = 1.132/20.4 = .0555
(Between sta. 7 & sta. 53)
Planimetered average = 3.02/9.97 = .303
(Between sta. 7 & sta. 53)
8 unit pitot S.H. L.V. #1
(Excess of pitot S.H. over 8 unit)
Slope = 1:20.4
Pitot impact - L.V. #2
(Slope = 1:9.97)
South wall of tunnel
North wall of tunnel
Distance from wall "Inches"

FIGURE 20



VERTICAL TRAVERSE
5 tunnel with 1/4" pitot - static tubes
Static holes 85" ahead of plane of N.R.L. balance
Whalen gage connected to δ unit static plates
δ unit static plate pressure = 9.0" alcohol (.8207 density)
Date of test - Feb. 19, 1929
Planimetered average = .0423
(Between sta. 7 & sta. 53)
Planimetered average = .291
(Between sta. 7 & sta. 53)
δ unit-pitot S.H. - L.V. #1
(Excess of pitot S.H. over δ unit)
Slope = 1:20.4
Pitot impact - L.V. #2
(Slope = 1:9.97)
Bottom of tunnel
Top of tunnel
Distance from wall "Inches"
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0

FIGURE 21

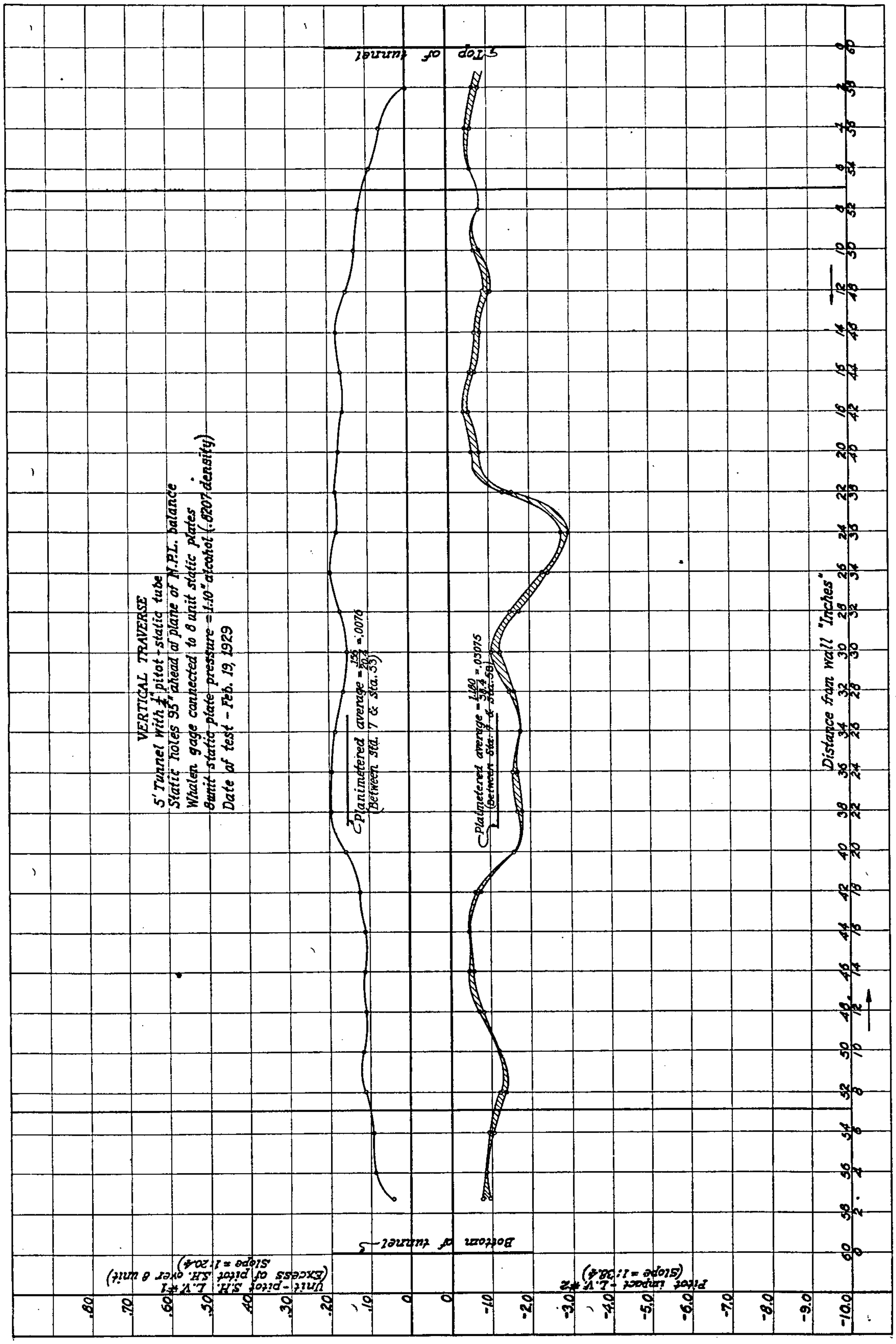

VERTICAL TRAVERSE
5' Tunnel with 1/4" pitot-static tube
Static holes 95" ahead of plane of N.P.L. balance
Whalen gage connected to 8 unit static plates
8 unit static plate pressure = 1:10" alcohol (.8207 density)
Date of test - Feb. 19, 1929
Planimetered average = .156/20.4 = .0076
(Between Sta. 7 & Sta. 53)
Top of tunnel
Bottom of tunnel
Distance from wall "Inches"
Unit - pitot S.H. L.V. #1
(Excess of pitot S.H. over 8 unit)
Slope = 1:20.4
Pitot impact - L.V. #2
(Slope = 1:30.4)

FIGURE 22