Experimental graduation of a Pitot tube for determining the velocity of flow of air in stacks

THESIS.

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G.T. LEE. 1904 J. Bryant HEARD.

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Approved by

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W.N.C

EXPERIMENTAL GRADUATION OF A PITOT TUBE FOR DETERMINING THE VELOCITY OF FLOW OF AIR IN STACKS.

Prof. S. W. Robinson in discussing the theory of the Pitot Tube says - "The theory of the instrument is that given by Pitot and is simply this, viz.: that the difference of level of two columns is the height due to the velocity of the current driving against the direct opening of the tube. Hence v 2gh where (v) is the velocity sought; (g) is the acceleration of gravity and (h) is the diffenence of level of the two columns."

The resultant velocity and pressure head can be accurately measured by this instrument. It consists essentially of two tubes, one opening to squarely face the moving currents and the other entering at right angles to it, by this we measure the pressure head and the velocity head plus the pressure head and by substraction obtain the velocity head.

DESCRIPTION OF APPARATUS.

(Accompanied by sketches.)

We procured a wooden box 1' x 1-1/2' x 8' (used as a mock stack) through which we forced a current of hot air(about the temperature of an ordinary stack) by means of a reostat and an artificial draft. The rehostat heated the air and at each end of the box was placed a thermometer for measuring the temperature of the incoming and outgoing air. The rehostat has sufficient current supplied to it to give any desired range of temperature under 500 degrees F. The artificial draft was obtained from an induction fan and by means of a button we could regulate the speed of the fan.

We measured the current and the electro-motive force (also watts, as a check) and by converting them into watt units furnished a direct means for determining the velocity of air in the box. used a formula which is explained as follows:

LET

W = watts spent in heating air
C = caefficient for converting watts into B.T. U. S.
V = volume of air passed
W = weight of cubic foot of air
S = specific heat of air
T = temperature of discharged air
T = temperature of entering air

THEN:

$$\frac{W}{C} = V \times W \times S \times (T - T)$$

from which V can be determined for any desired time and dividing this by our cross-section we obtain the velocity. An anemometer was used as a check upon our results.

(C) was found thus:

746 watts = 33000 foot pounds
1 B.T.U. = 778 foot pounds
1 B.T.U. = 17.5 watts

We obtained a current of 9.4 amperes under a pressure of 80 volts which gave about 750 watts. Now with a difference of temperature of 140 degrees F registered by the thermometers and our data, we can solve for V

$$\frac{W}{C} = V \times W \times S \times (T - T)$$

Substituting

$$\frac{750 \times 60}{17.5} = V \times .076613 \times .1691 \times 140$$

V = 1400 ft. per minute

$$\frac{\text{volume}}{\text{area}} = \text{velocity}$$

$$\frac{1400}{1.5} = 935 \text{ ft, per minute}$$

The deflection on our tube corresponding to this velocity was 1/2". Now in this way several different velocities were found and in each case our claculated velocity and anemometer reading did not vary more than from 15 to 30 feet per minute.

The ordinary U tube having been found insufficiently carrurate with our limited conditions attending the test, an ingenious arrangement was devised, which is based on the following principal:

In the accompanying sketch we have two tin cups 1" in diameter directly connected to a glass tube 1/8" in dianeter and 20" long in which is a bead of air which serves as a recorder for our multiplies pressure. Our Pitot tubes were 1/2" in diameter and directly connected to our cups. Now from the simple rule of physics that the pressure depends only upon the head and not the quantity of water, the height displaced in the cup will be the same as if we had a U tube; but since the cup is larger the quantity of water displaced is increased and this forms one portion of our multiplying arrangement.

Another portion is derived from the relation of the diameter of the cups to the recording tube which varies as the square of the diameters.

From the top of the stack (V. P. I.) we obtained the maximum flow of the gases and also obtained the maximum deflection by inserting our tube near the same place. From this data, we found a cup 1" in diameter and a recording tube 1/8" in diameter which by calculation will fit the existing conditions.

We took our current from the direct machine and in the accompanying sketch we have a watt meter, anemeter, rehostat, and a water rehostat in series. To the pressure coil of our watt meter we have a volt meter in parallel. We used a water rehostat ~~to~~ to gradually bring up our current and thus protect our rehostat in the end of the wooden box. Our induction fan~~s~~ was supplied with alternating current.

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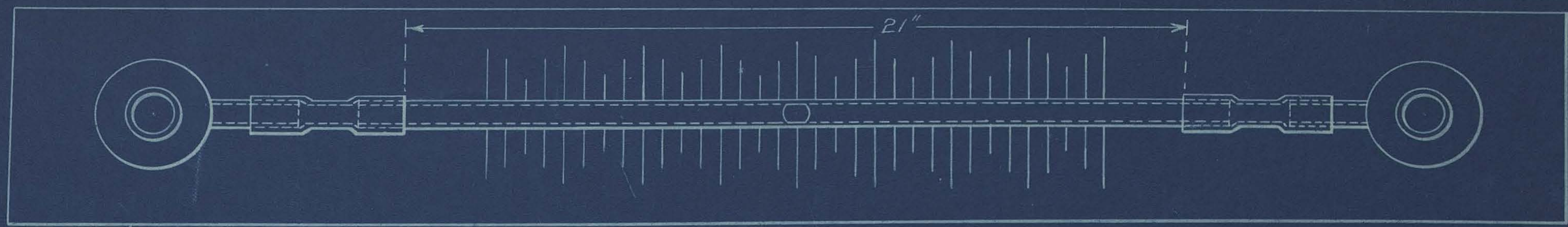
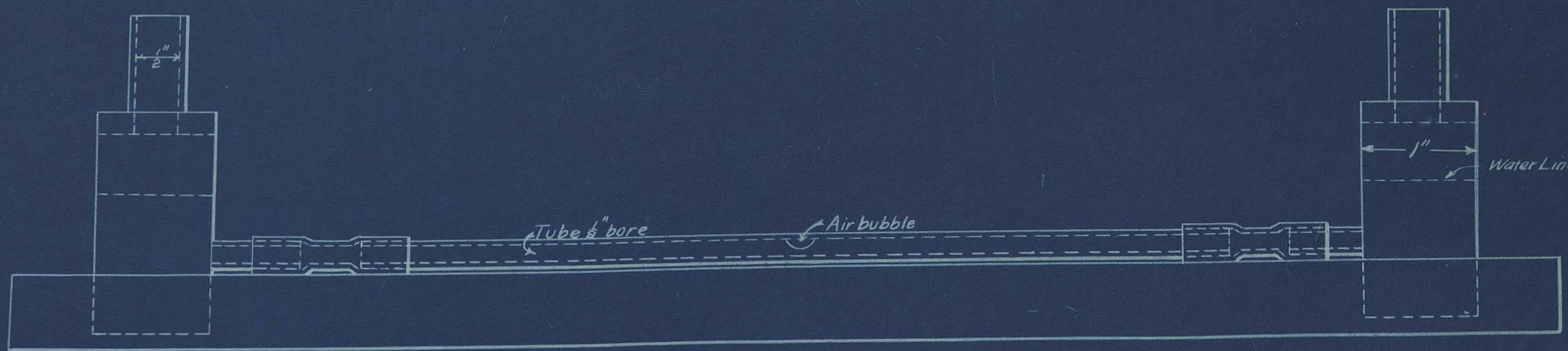
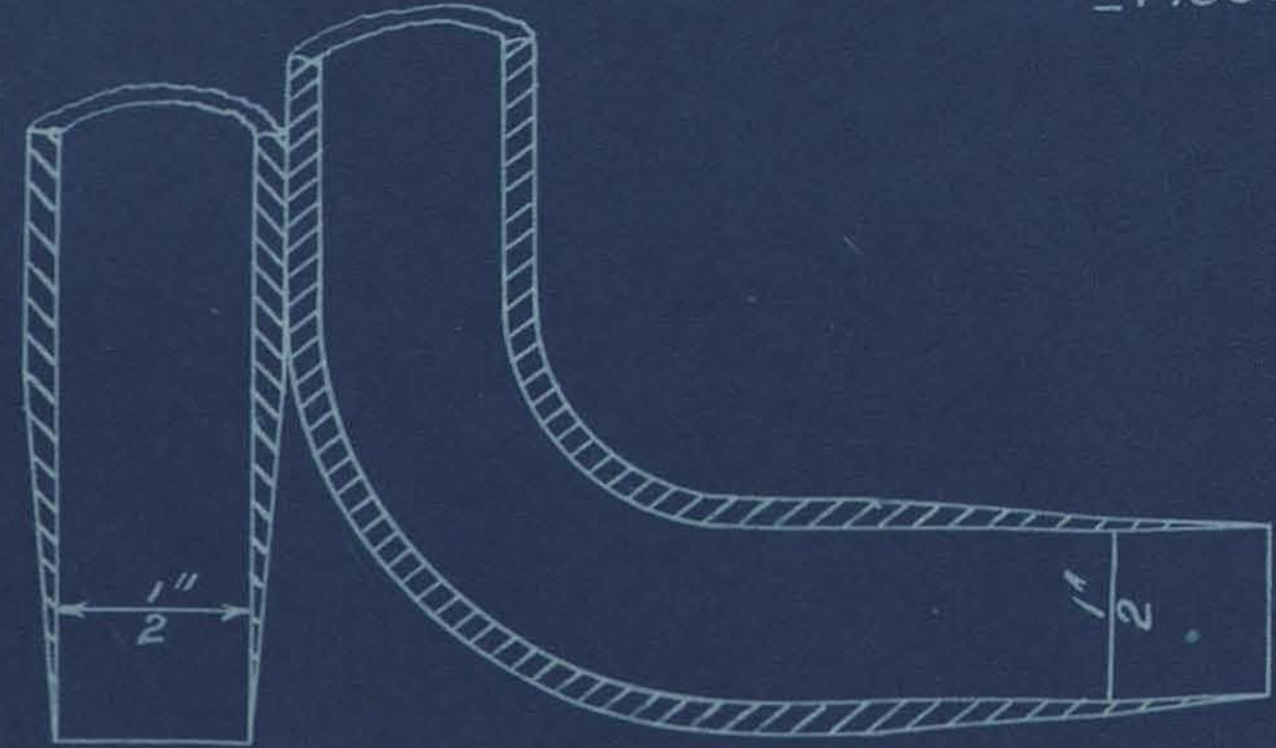




Recording Arrangement



Orifice of Pitot Tube

DETAILS of APPARATUS

ASSEMBLED DRAWING
OF
APPARATUS

Including:

Connections for Rheostat, and Artificial draft also Sketches of Mock Chimney, Pitot tubes and recording U tube.