Code 415

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

S1/1-2(415)
DDS3801-4

From: Chief, Bureau of Ships
To: All Holders of Design Data Books,
BuShips Mailing List 415.

1. This design data sheet is for use in connection with section S38-1, General Specifications for Ships.

By direction

DESIGN DATA SHEET
DDS3801-4
DESIGN OF SLOTTED DUCT TERMINALS

DDS3801-4-a. General

1. This design data sheet presents a method for designing slotted duct terminals.

2. The term "pressure loss" as used herein is always a total pressure loss in "inches of water, gage".

DDS3801-4-b. Definition of symbols

- Θ - Resultant direction of air discharge - degrees
- Pt - Total pressure - 3" upstream of slot - inches H_2O
- Vs - Average velocity of air at discharge from slot - FPM
- Q - Quantity - CFM
- D - Diameter of round supply duct - inches
- Hs - Width of slot - inches
- Ls - Length of slot - feet
- Wd - Width of rectangular supply duct - inches
- Hd - Height of rectangular supply duct - inches

DDS3801-4-c. Design procedure

A straight line across the scales, figure 1, for certain sets of 3 variables, intercepts the scales in a simultaneous solution for these three variables. The sets of three variables so related are as follows:

(a) Θ, Pt, Vs
(b) Vs, Q, Reference
(c) Reference, D, Θ
(d) Reference, Hs, Ls
(e) D, Hd, Wd

Lines 1, 2 & 3, Fig. 1, with common intercepts on Θ (left), Vs, Reference and Θ (right) constitute a solution for the variables in subparagraphs (a), (b) and (c) above. With this solution, various combinations of the variables in subparagraph (d) line 4, Fig. 1 and subparagraph (e) are possible. Note that there are two separate scales for Θ; any valid solution must cross both Θ scales at the same value.

Example 1.

Sketch A shows a typical problem. The space is an air control center on a submarine. Personnel with exacting tasks are located throughout the space. Minimum draft, minimum blast on personnel, minimum terminal noise, most effective diffusion, are all very important considerations. The cooling solution requires delivery of 2500 CFM to the space. The fan and coil are located below and air can be delivered via a conveniently located mast trunk; slotted ducts can be conveniently located as shown.

Air delivery prorated to the length of the slotted ducts, as shown, will provide adequate distribution in the space. Thus, there are four slotted ducts to design.

Taking the 20 foot duct first, it is found that Q = 860 CFM. A broad pattern, similar to figure 2 of sketch B is desired, therefore, set Θ at 75° minimum.

Design requirements are low noise and no blast on personnel, therefore, set Vs at 800 FPM. Plot these values on figure 2, plotting Θ on both scales, and connect the related points (line 1). The slot width is .65 inches, therefore, acceptable. The pressure loss, for a sharp edge slot, is .12 inches H_2O, acceptable. The duct diameter, however, is 17 inches, too large for the available space. Note that the use of a round edge slot would reduce the pressure loss, which is unnecessary, and increase the duct size which is unacceptable.

The largest practical duct diameter is 10 inches. With a discharge velocity of 800 FPM the resultant Θ would be 55°, which is too low. Both Θ and Vs must be accommodated to the limited space for the duct. Try Θ = 65°. Vs then becomes 1230 FPM, high, but acceptable, Pt becomes .35, acceptable, and Hs becomes .41 inches (line 2).

In designing the 8 foot duct, Pt should be the same as that used in the 20 foot duct to avoid the need for a pressure balancing orifice in the 8 foot branch. For simplicity of fabrication, the duct sizes should be the same. Therefore, it would be desirable to hold Q = 340 CFM, Ls = 8', Pt = 0.35 and D = 10". Q is given, Ls is given, Pt is set by the 20 foot solution; therefore, Θ, Vs and D are the variables. Holding Q, Ls, Pt and D requires that Θ decrease and Vs increase, both undesirable. Therefore, hold Vs = 1230 FPM and Θ = 65°. The resulting D = 6.4" and Hs = 0.43" are satisfactory (line 3).

For the other two ducts, it is desired to get a higher Θ and a lower Vs, which require a lower Pt. It is possible to slightly reduce Pt, providing the difference in pressure loss can be satisfactorily designed into the two branches. With Pt = .25", arbitrarily choose Θ = 75°, which results in Vs = 1160 FPM, both satisfactory values for the 18 foot duct. D then becomes 13", which is suitable for the space, and Hs = .45" (line 4). Solutions for the 12 foot duct will be made in the same manner as the 8 foot duct, resulting in D = 11" and Hs = .45" (line 5).

The following are the first solution:

Q	L	D	Hs
860	20'	10"	.4
340	8'	6.4"	.43
780	18'	13"	.45
520	12'	11"	.45

For each branch a suitable equivalent rectangular duct with dimensions to the nearest inch or half inch should be selected. Slot widths to eighths or sixteenths should be determined: in this case, it appears that 7/16" would serve for all four ducts. The solution should then be checked by working backward to equivalent D for each duct, using final Hs, and holding approximate Q and approximate Θ to obtain a new pressure extimate for each pair of ducts. The remaining ductwork of the system is then designed to give the required pressure at the entrances to the slotted ducts.

Example 2

Sketch C shows a typical problem in designing the supply plenum for a submarine battery exhaust system. The plenum is to be installed using the space between two transverse deck frames, which are spaced 24" on centers, are 4" deep and are 12' long. The natural supply connection will enter the plenum two feet from one end. The required volume is 1800 CFM. The discharge velocity should be high and normal to the centerline, to insure good distribution in the battery tank.

Prorating airflow to the duct length and starting with the long branch:

Q = 1500 CFM
L = 10'
Θ = 75° minimum
Hd = 4"
Wd = 24"

Plot these values (as shown on figure 3, line 6).

The equivalent diameter is 11" D, the velocity of discharge will be 3250 FPM, acceptable, but the pressure loss will be 1.9", much higher than allowable. The 4" x 24" space between the deck frames is obviously too small.

Lower the bottom of the plenum by 4", to give a space 8" x 24". This increases the equivalent diameter to 15-1/2", Vs becomes 1600 FPM, acceptable, and Pt becomes .46", acceptable. Hs is 1.1" (line 7).

For the two foot duct, it would be desirable for simpli-ity's sake to continue the same duct cross section and the same slot width. Θ then becomes about 85°. The pressure at the inlet will be the same for both ducts. Vs will then be increased to about 1600 FPM and Q to about 320 CFM (line 8). This is an acceptable solution.

An alternate solution using only the four inch space for the 2 foot duct would also be possible by narrowing the slot in the 2 foot portion to about .125".

The use of the publications listed below in the preparation of this design data sheet is acknowledged:

(a) "Report of Investigation to prepare a Design Chart for slotted ducts used as air supply terminals" MATLAB NYKNAVSHIPYD Project 5455 Final Report.

(b) "The Discharge of Air from a Long Slot" by Alfred Koestel and G. L. Tuve, Research Paper No. 1328, Transactions ASHVE, Vol. 54, 1948.

(c) "Jets and Inlets in Ventilation" by P. Becher, Journal of the Institution of Heating and Ventilating Engineers, Vol. 18, May 1950, pages 107 through 119 published by Institution of Heating and Ventilating Engineers, 107 Carlton Ave., Preston Road, Wembley, England.

(d) "Comparative Study of Ventilating Jets from Various Types of Outlets" by Alfred Koestel, Philip Hermann, and G. L. Tuve, Research Paper No. 1404, Transactions ASHVE, Vol. 56, 1950, pages 459 through 478

(e) "Ventilation Jets in Room Air Distribution", 3 Volumes, by H. B. Nottage, Ph.D. Thesis, Case Institute of Technology, loan copy from ASHVE.

(f) "Control of Air Streams in Large Spaces" by G. L. Tuve and G. B. Priester, Research Paper No. 1248, Transactions ASHVE, Vol. 50, 1944, pages 153 through 172.

(g) "Heating, Ventilating, Air Conditioning Guide, 1953", published by American Society of Heating and Ventilating Engineers, Chapter 31.

(h) "Throw of Air from Slots and Jets" by R. D. Madison and W. R. Elliot, Heating, Piping and Air Conditioning, Vol. 18, Nov. 1946, pages 108 through 109.

(i) "Air Distribution and Draft" by John Rydberg and Per Norback, Research Paper No. 1362 Transactions ASHVE Vol. 55, 1949.

(j) "The Control of Air Streams from a Long Slot" by A. Koestel and Chia-Yung Young, Heating, Piping and Air Conditioning, Vol. 23, July 1951, pages 111 through 115.

(k) "Air Velocities in Ventilating Jets" by G. L. Tuve, Heating, Piping and Air Conditioning, Vol. 25, Jan 1953, pages 181 through 191

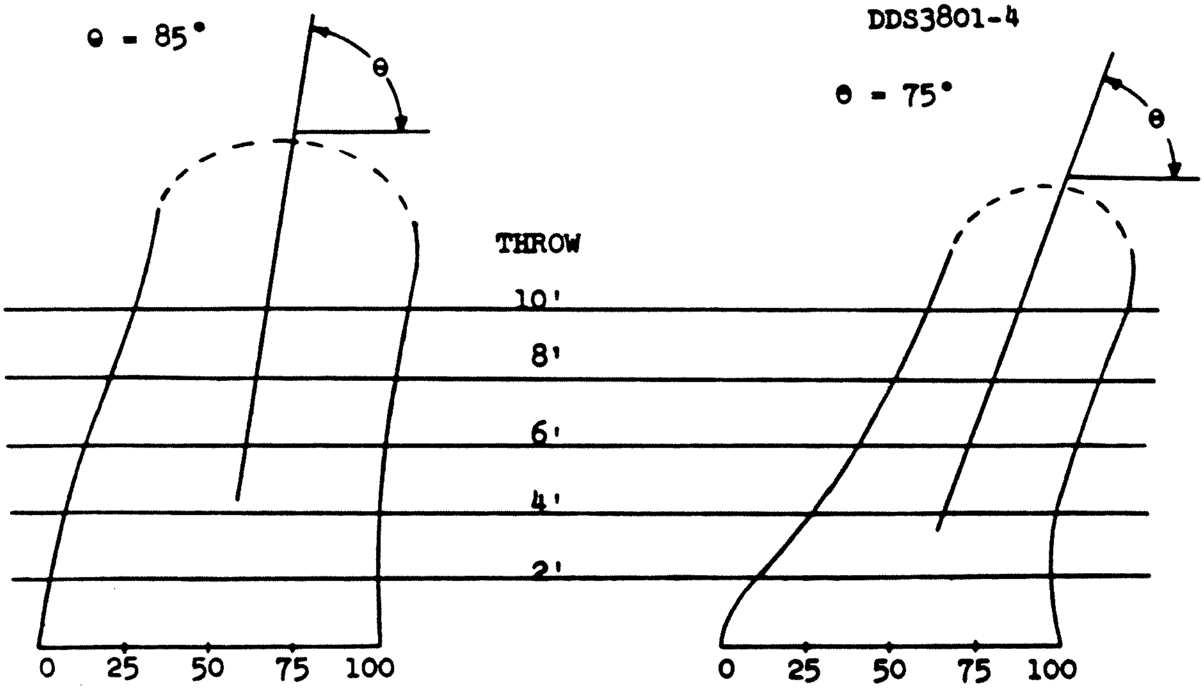


FIG. 1

% OF LENGTH OF SLOT

FIG. 2

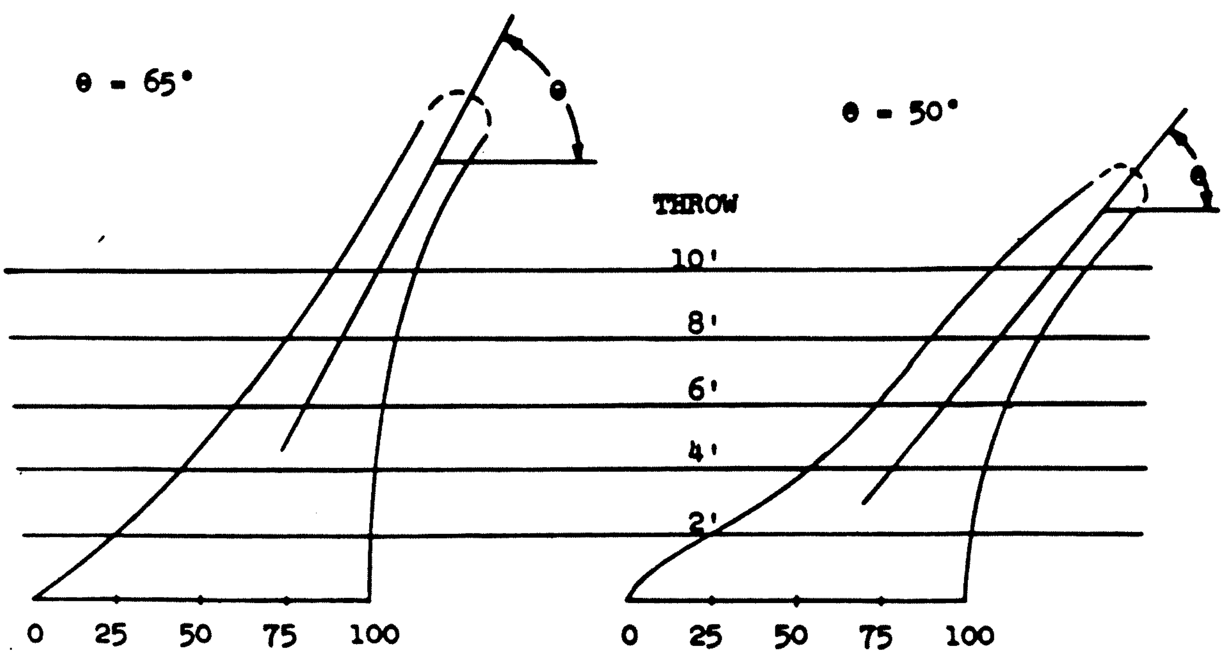
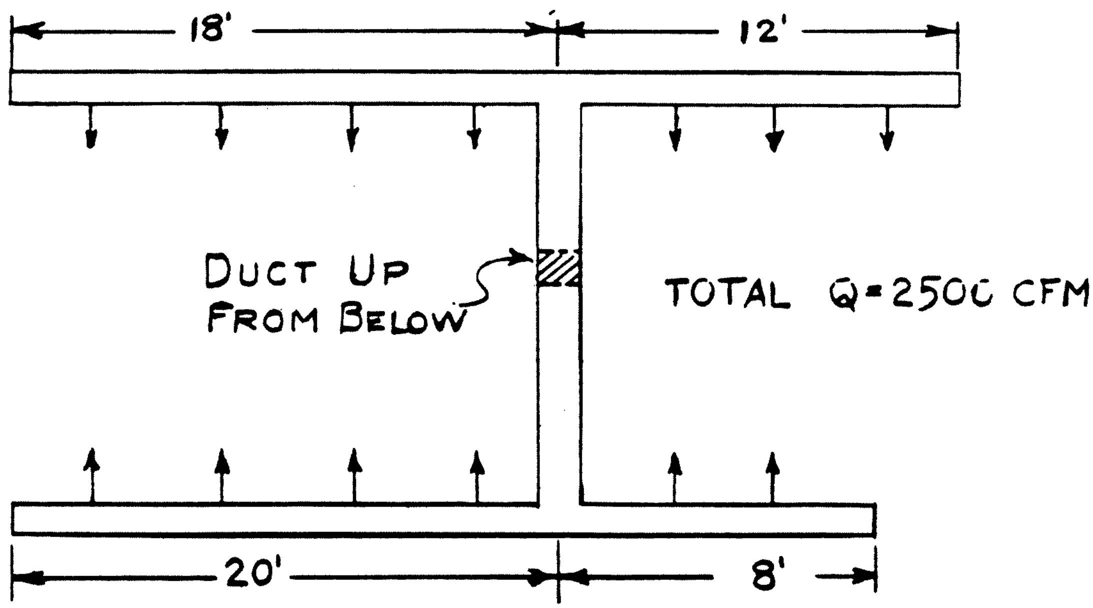


FIG. 3

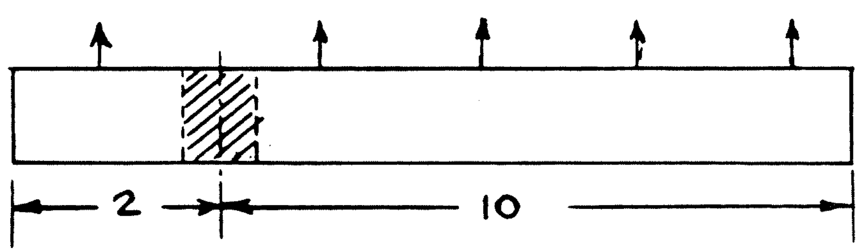
FIG. 4

% OF LENGTH OF SLOT

SKETCH B



SKETCH A



SKETCH C

Q = 1800 CFM
L = 12'
$\Theta_{MIN.} = 75°$

NOMOGRAM - SLOTTED DUCT DESIGN

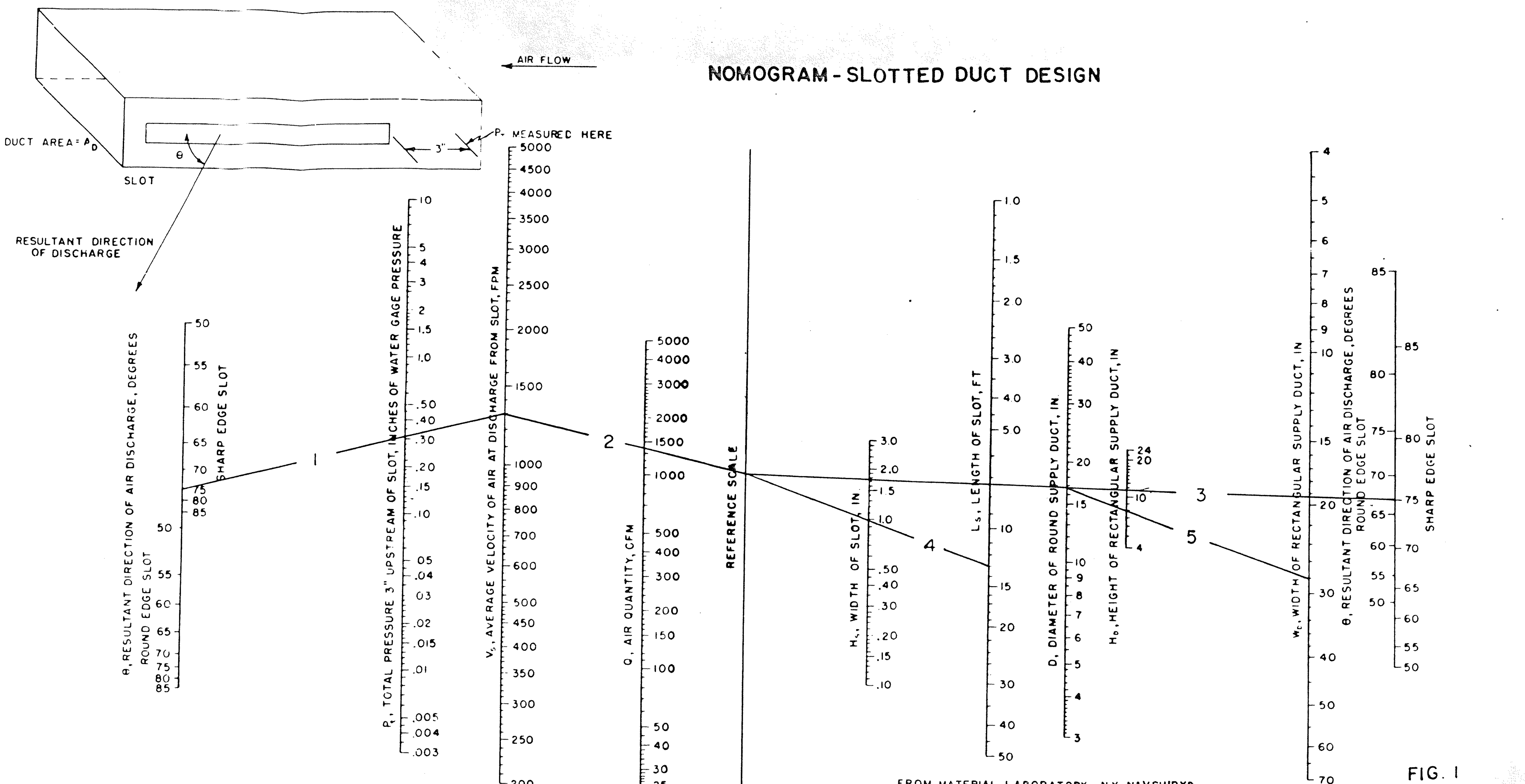


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FIG. 1

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NOMOGRAM - SLOTTED DUCT DESIGN

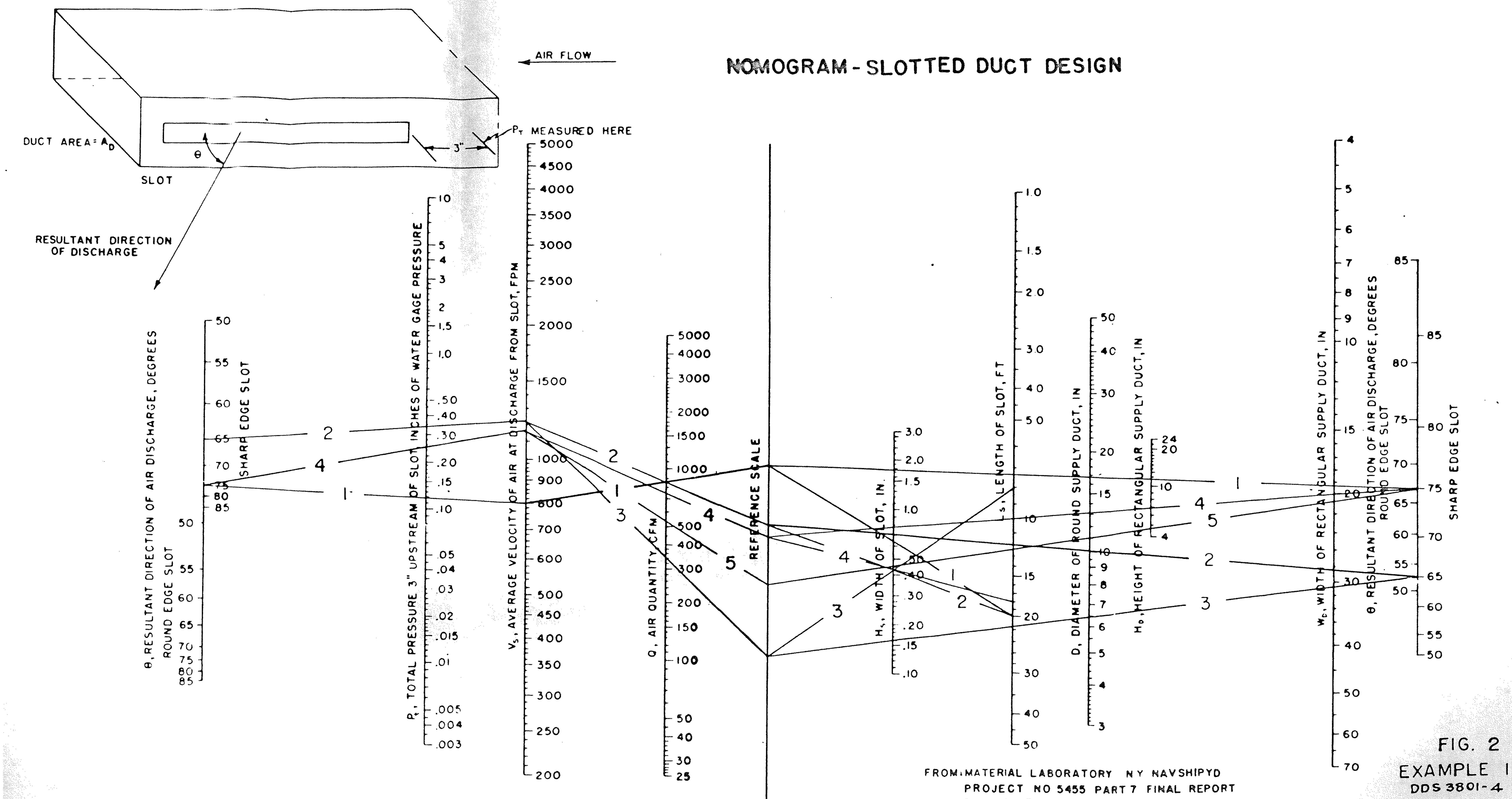

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FIG. 2
EXAMPLE 1
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NOMOGRAM - SLOTTED DUCT DESIGN

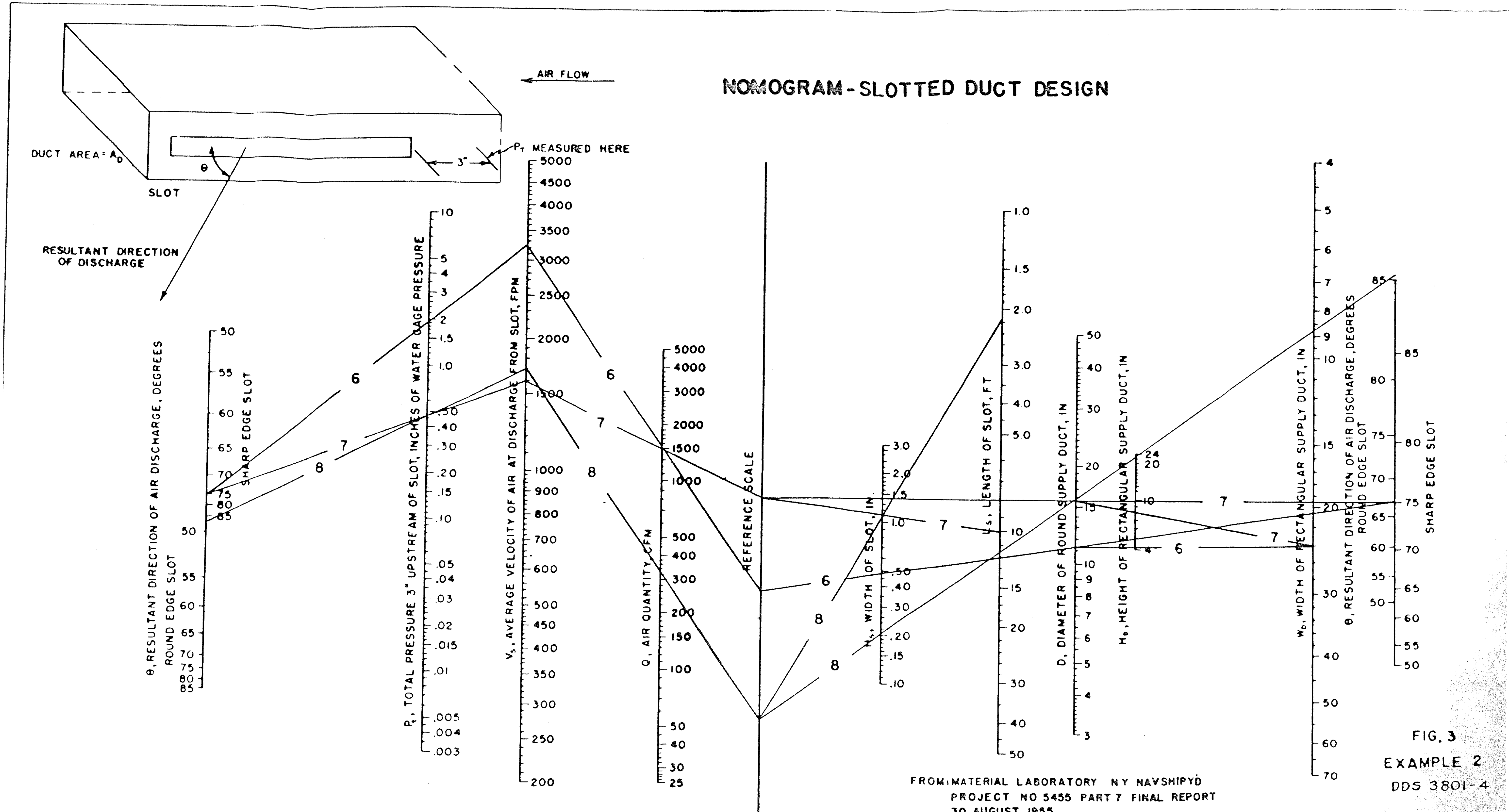

FIG. 3

EXAMPLE 2

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