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Final Report

DETERMINATION OF THE SOUND TRANSMISSION CHARACTERISTICS OF VARIOUS AIRCRAFT SOUNDPROOFING MATERIALS

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FOREWORD

The experimental program was initiated under the direction of R. N. Hamme* and was concluded under the direction of J. C. Johnson, Project Supervisor.

The author wishes to acknowledge the advice and assistance rendered by N. E. Barnett and H. F. Reiher* and to make note of the technical assistance of W. O. Bailey, G. Eberle,* and R. Kriewall.** The data reduction and the drafting were accomplished by W. O. Bailey and M. E. Kirchoff, with the secretarial service provided by Mrs. A. D. Simms.

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**Now with the U. S. Navy.

ABSTRACT

Determination of the sound transmission characteristics for various aircraft fuselage acoustic treatments was accomplished utilizing a small sample transmission-loss apparatus. The materials tested were ranked in relation to the theoretical weight-law attenuation of a 0.020-inch-thick dural panel.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

RANDALL D. KEATOR
Colonel, USAF
Chief, Aircraft Laboratory
Directorate of Laboratories

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LIST OF ILLUSTRATIONS*

*See Table I.

INTRODUCTION

This report covers the work done under Contract No. AF 33(616)-3435 between Wright Air Development Center and The University of Michigan, and in general follows the principles of experimentation presented in two previous reports, namely, "Report on Sound Transmission Through Aircraft Wall Structures," P. H. Geiger, R. N. Hamme, Contract W33038 ac-14775, November 10, 1947, and "Sound Transmission Through Aircraft Soundproofing Structures," P. H. Geiger, R. N. Hamme, Contract AF 33(038)-2652, October 27, 1949. Thus only a brief description of the apparatus and the procedure is presented in this report. The types of materials tested under this contract include acoustical tapes, plastic-back blankets, polyurethane sheets, and various honeycomb configurations. The results obtained using these materials are tabulated in the Summary of Results.

EXPERIMENTAL APPARATUS AND PROCEDURE

APPARATUS

Essentially, the transmission testing apparatus, as shown in Figure 1, consists of two separate enclosures. One is an acoustically live source chamber and the second, a highly absorbent or anechoic termination. The source chamber consists of a 30-inch concrete cube through which a 17.5-inch square hollow traverses. For access purposes one end of the hollow is blocked by a securely bolted 0.25-inch steel plate. The acoustic source consists of a bank of sixteen series-parallel 4-inch dynamic speakers mounted on a single frame for sound excitation in the range from 58 cps through 2700 cps. In addition twin tweeters are used to provide a reliable source from 2890 cps through 8800 cps. A crystal microphone (A) is used to monitor the sound pressure level in the source chamber. The termination closure is composed of a tube 18.5 inches square and 8 feet long closed at one end and packed with a sound-absorbing material. An acoustic pick-up (B) is located at the face of the open end. The make-up of the linking structure between the two enclosures is largely determined by the material to be tested. The open end of the source chamber is framed by a 0.25-inch steel section. The 0.020-inch-thick dural standard is then mounted over the opening and held in place by smooth-surfaced one-inch steel bars bolted into place. Four studs, one at each corner, are imbedded in the concrete bordering the open face of the source chamber. Over these studs are placed the appropriate wooden spacer frames and the

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sample. The trim cloth then covers the sample face and the termination is butted against the sample.

The instrumentation consists of the source-drive electronics and the termination-response analysis system. The source drive is provided by a warble oscillator, the center frequency of which is set to the desired value with the aid of an oscilloscope and a secondary-standard oscillator. The output of the warble oscillator is then amplified, monitored, and applied to the speaker system.

The analysis system is used to measure the relative sound pressure levels existing in the source and termination enclosures. The signal from A or B (see Figure 1) is fed successively through a preamplifier, intermediate amplifier, filter, and final amplifier. The final output is then read from a db meter and can be monitored aurally.

PROCEDURE

The 0.020-inch dural panel is first securely attached at the opening of the source chamber. The termination enclosure is sealed to the source chamber and calibration data (A-B) is then obtained for the panel. Next, appropriate spacer frames are added to the face of the source chamber in order that a 3-inch space be maintained between the dural panel and the outside face of the treatment, except for the acoustic tapes which were applied directly to the 0.020-inch dural panel. After securing the termination enclosure, transmission-loss data are obtained for the combination of the dural panel and the treatment (B-A).

PRESENTATION OF DATA

Since twenty-four separate acoustic treatments were tested, it was decided to assign a reference structure number to each treatment to avoid confusion. The descriptive information is shown in Table I where the composition of each structure is described and assigned both a structure number and a figure number, the latter being a key to the graphic presentation of the transmission-loss data obtained for the accompanying structure. In these figures (3-26) two sets of data are plotted. The straight line represents the theoretical weight-law attenuation for total treatment including the dural panel, while the broken line represents the algebraic sum of the transmission-loss values observed for the sample and the theoretical attenuation values of the dural standard. Thus, the difference between these curves indicates the actual transmission loss contributed by the treatment itself. This data presentation is consistent with that of the two previous reports.

SUMMARY OF RESULTS

It must be noted that transmission-loss data for the various configurations tested are of a relative nature and are presumed to differ from absolute values by a certain constant which is, as yet, undetermined. This is true except for the honeycomb structures, which upon their introduction into the testing system result in a change in the system from a basic single-wall structure to an enigmatic double-wall configuration. Therefore no positive correlation of data is anticipated between the transmission-loss results obtained for the honeycomb structures and those obtained for the tapes, polyurethane sheets, and quilted blankets, using the present transmission-loss apparatus.

Besides the transmission-loss data shown in Figures 3-26, several additional transmission characteristics for the materials tested have been computed. Average attenuation for the Merit-Factor range of 2890-8800 cps and for the Q range 1830-5400 cps have been computed for each test and are presented at the base of each attenuation figure. Furthermore, the data are compared with theoretical weight-law attenuation values at 5000 cps and 3000 cps, which are the midpoint frequencies of the Merit Factor and the Q Factor ranges, respectively. In addition, the Merit Factor and the Q Factor have been determined for each sample, thus taking into account the importance of the treatment weight in selecting an efficient soundproofing structure. These factors may be defined as follows:

$$\text{Merit Factor} = \frac{\text{db average attenuation 2890-8800 cps better than weight law at 5000 cps}}{\text{treatment weight}}$$

$$\text{Q Factor} = \frac{\text{db attenuation 1830-5400 cps better than weight law at 3000 cps}}{\text{treatment weight}}$$

The foregoing data are summarized in Tables II and III. Table II lists the data computed for each structure in sequence according to the structure number, while Table III groups the transmission-loss characteristics of each class of structures according to their treatment weight.

CONCLUSIONS

As has been stated previously, there is no valid correlation between the honeycomb structures and the various other configurations tested. However, if a similarity in the test configuration can be construed to permit valid comparison of transmission-loss data for similar structural materials, then the data obtained for the honeycomb panels may be evaluated, one against another. From Table III it can be seen that, with an increase in the thickness of the honeycomb panel, there is a general decrease in the value for the average attenuations in the Merit and Q Factor ranges minus the appropriate theoretical weight-law attenuation values. This means that for these frequencies the panels become relatively less efficient with increasing weight and thickness. This is also shown by the computed Merit and Q Factors. That this should be the case is indeed a matter of conjecture, and emphasizes once again the inherent value of a testing program yielding absolute transmission-loss data.

Of the other structures and materials tested, both the polyurethane and quilted-insulation blankets demonstrate larger db-better-than-weight-law values in the Merit and Q Factor ranges than do the tapes. This is shown also by the relatively large Merit and Q Factors obtained from both the polyurethane and blanket data; the polyurethane structures show a predominance of efficiency in these frequency ranges.

The tests reported above discriminate against displaying the important attribute of acoustic tapes, which is to provide supplementary vibration damping to the treated structure. In panel transmission measurements, a treatment which provides damping inhibits excessive transmission at frequencies corresponding to the natural resonances of the panel, the transmission loss at these frequencies approaching theoretical weight-law values in the limit with increased damping. However, the bare dural panel in the present transmission apparatus does not exhibit any pronounced resonance phenomena within the test-frequency range, and consequently, the only important remaining effect of a damping-tape treatment is an increase in the effective weight of the panel. For example, a comparison of structures Nos. 1 and 2 shows that the average increase in attenuation due to three additional layers of tape is 5.0 and 5.1 db, respectively, for the 2890-8800 cps and the 1830-5400 cps ranges. The theoretical increase in attenuation to be expected from the increased effective weight of the panel amounts to 5.4 db. The poor Merit and Q Factor values yielded by the acoustic-tape treatments is the result of the nonapplicability of this measure for the effectiveness of damping treatments.

TABLE I

DESCRIPTION OF SOUNDPROOFING STRUCTURES

Structure No.	Composition*	Figure Reference
1	Acoustimat Tape, 1 thickness	3
2	Acoustimat Tape, 4 thicknesses	4
3	Minnesota Mining Aluminum Tape 36PSL15231IL82, 4 thicknesses	5
4	Polyurethane, 1/8-inch thickness	6
5	Polyurethane, 1/4-inch thickness	7
6	Polyurethane, 3/8-inch thickness	8
7	Acoustimat Tape, 4 thicknesses, plus polyurethane, 1/8-inch thickness	9
8	Acoustimat Tape, 4 thicknesses, plus polyurethane, 3/8-inch thickness	10
9	Insulation Blanket, Quilted, 5640-269-9388, 3/8-inch thickness, Type I	11
10	Insulation Blanket, Quilted, 5640-269-1179, 1/4-inch thickness, Type II	12
11	Insulation Blanket, Quilted, 5640-269-1049, 1/4-inch thickness, Type II	13
12	Honeycomb panel, cotton core, 7/16-inch cell size, 0.016-inch dural skin, 3/8-inch thickness	14
13	Honeycomb panel, cotton core, 7/16-inch cell size, 0.016-inch dural skin, 1/2-inch thickness	15
14	Honeycomb panel, cotton core, 7/16-inch cell size, 0.016-inch dural skin, 1-inch thickness	16

*All include 0.020-inch dural panel.

TABLE I
(concluded)

Structure No.	Composition*	Figure Reference
15	Honeycomb panel, cotton core, 7/16-inch cell size, 0.020-inch dural skin, 3/8-inch thickness	17
16	Honeycomb panel, cotton core, 7/16-inch cell size, 0.020-inch dural skin, 1/2-inch thickness	18
17	Honeycomb panel, cotton core, 7/16-inch cell size, 0.020-inch dural skin, 1-inch thickness	19
18	Honeycomb panel, cotton core, 7/16-inch cell size, 0.025-inch dural skin, 3/8-inch thickness	20
19	Honeycomb panel, cotton core, 7/16-inch cell size, 0.025-inch dural skin, 1/2-inch thickness	21
20	Honeycomb panel, cotton core, 7/16-inch cell size, 0.025-inch dural skin, 1-inch thickness	22
21	Honeycomb panel, fiberglass core, 1/4-inch cell size, 0.016-inch dural skin, 1-inch thickness	23
22	Honeycomb panel, fiberglass core, 1/4-inch cell size, 0.020-inch dural skin, 1-inch thickness	24
23	Honeycomb panel, fiberglass core, 1/4-inch cell size, 0.025-inch dural skin, 1-inch thickness	25
24	Honeycomb panel, metal core, 1/2-inch thickness	26

*All include 0.020-inch dural panel.

TABLE II

SUMMARY OF TRANSMISSION-LOSS CHARACTERISTICS ACCORDING TO STRUCTURE NUMBER

Structure*	Total Weight	Treat. Weight	2890-8800 cps Av. Att.	2890-8800 cps Wt. Law	1830-5400 cps Av. Att.	1830-5400 cps Wt. Law	Merit Factor	Q Factor	db Better Than Weight Law MF Range	db Better Than Weight Law Q Range
1	0.4385	0.1585	44.4	44.1	40.0	39.6	1.89	2.31	0.3	0.4
2	0.7819	0.5019	49.4	49.1	45.1	44.7	0.56	0.84	0.3	0.4
3	0.7472	0.4672	52.8	48.7	48.1	44.3	8.78	8.13	4.1	3.8
4	0.3616	0.0816	50.3	42.4	44.8	38.0	96.3	84.1	7.9	6.8
5	0.3982	0.1182	54.8	43.3	47.6	38.8	97.4	73.7	11.5	8.8
6	0.4217	0.1417	59.8	43.7	53.8	39.3	113.0	102.0	16.1	14.5
7	0.8194	0.5394	56.4	49.5	51.5	45.1	12.8	11.9	6.9	6.4
8	0.8795	0.5995	67.7	50.1	60.9	45.7	29.2	25.4	17.6	15.2
9	0.5106	0.2306	64.2	45.4	56.6	41.0	81.5	67.6	18.8	15.6
10	0.5257	0.2457	63.7	45.7	58.0	41.2	73.3	68.4	18.0	16.8
11	0.4592	0.1792	61.9	44.5	53.9	40.1	97.1	77.0	17.4	13.8
12	1.1119	0.8319	63.2	52.2	60.4	47.7	13.2	15.3	11.0	12.7
13	1.2519	0.9719	63.8	53.2	59.3	48.6	10.9	11.0	10.6	10.7
14	1.5019	1.2219	64.6	54.8	60.5	50.3	8.02	8.35	9.8	10.2
15	1.2769	0.9969	64.8	53.4	61.7	48.9	11.4	12.8	11.4	12.8
16	1.2899	1.0099	64.7	53.4	60.6	49.0	11.2	11.5	11.3	11.6
17	1.5899	1.3099	63.9	55.3	59.5	50.8	6.57	6.64	8.6	8.7
18	1.4339	1.1539	65.7	54.4	63.6	49.9	9.79	11.9	11.3	13.7
19	1.4619	1.1819	64.7	54.8	60.9	50.3	8.38	8.97	9.9	10.6
20	1.7119	1.4319	64.5	55.9	59.3	51.5	6.01	5.45	8.6	7.8
21	1.4169	1.1369	62.5	54.3	58.0	49.8	7.21	7.21	8.2	8.2
22	1.5099	1.2299	66.0	54.8	60.1	50.4	7.42	6.42	11.2	9.7
23	1.6269	1.3469	66.1	55.5	59.8	51.1	7.87	6.46	10.6	8.7
24	1.5169	1.2369	66.6	54.9	62.9	50.5	9.46	10.0	11.7	12.4

*See Table I.

TABLE III

SUMMARY OF TRANSMISSION-LOSS CHARACTERISTICS OF SIMILAR TREATMENT CONFIGURATIONS

Structure*	Treat. Weight	2890-8800 cps Av. Att.	2890-8800 cps Wt. Law	1830-5400 cps Av. Att.	1830-5400 cps Wt. Law	Merit Factor	Q Factor	db Better Than Weight Law MF Range	db Better Than Weight Law Q Range
				Tapes					
1	0.1585	44.4	44.1	40.0	39.6	1.89	2.31	0.3	0.4
3	0.4672	52.8	48.7	48.1	44.3	8.87	8.13	4.1	3.8
2	0.5019	49.4	49.1	45.1	44.7	0.56	0.84	0.3	0.4
				Polyurethane					
4	0.0816	50.3	42.4	44.8	38.0	96.3	84.1	7.9	6.8
5	0.1182	54.8	43.3	47.6	38.8	97.4	73.7	11.5	8.8
6	0.1417	59.8	43.7	53.8	39.3	113	102	16.1	14.5
				Tape plus Polyurethane					
7	0.5394	56.4	49.5	51.5	45.1	12.8	11.9	6.9	6.4
8	0.5995	67.7	50.1	60.9	45.7	29.2	25.4	17.6	15.2
				Insulation Blankets, Quilted					
11	0.1792	61.9	44.5	53.9	40.1	97.1	77.0	17.4	13.8
9	0.2306	64.2	45.4	56.6	41.0	81.5	67.6	18.8	15.6
10	0.2457	63.7	45.7	58.0	41.2	73.3	68.4	18.0	16.8
				Honeycomb Panels, 3/8-inch Thickness					
12	0.8319	63.2	52.2	60.4	47.7	13.2	15.3	11.0	12.7
15	0.9969	64.8	53.4	61.7	48.9	11.4	12.8	11.4	12.8
18	1.1539	65.7	54.4	63.6	49.9	9.79	11.9	11.3	13.7
				Honeycomb Panels, 1/2-inch Thickness					
13	0.9719	63.8	53.2	59.3	48.6	10.9	11.0	10.6	10.7
16	1.0099	64.7	53.4	60.6	49.0	11.2	11.5	11.3	11.6
19	1.1819	64.7	54.8	60.9	50.3	8.38	8.97	9.9	10.6
24	1.2369	66.6	54.9	62.9	50.5	9.46	10.0	11.7	12.4
				Honeycomb Panels, 1-inch Thickness					
21	1.1369	62.5	54.3	58.0	49.8	7.21	7.21	8.2	8.2
14	1.2219	64.6	54.8	60.5	50.3	8.02	8.35	9.8	10.2
22	1.2299	66.0	54.8	60.1	50.4	7.42	6.42	11.2	9.7
17	1.3099	63.9	55.3	59.5	50.8	6.57	6.64	8.6	8.7
23	1.3469	66.1	55.5	59.8	51.1	7.87	6.46	10.6	8.7
20	1.4319	64.5	55.9	59.3	51.5	6.01	5.45	8.6	7.8

*See Table I.

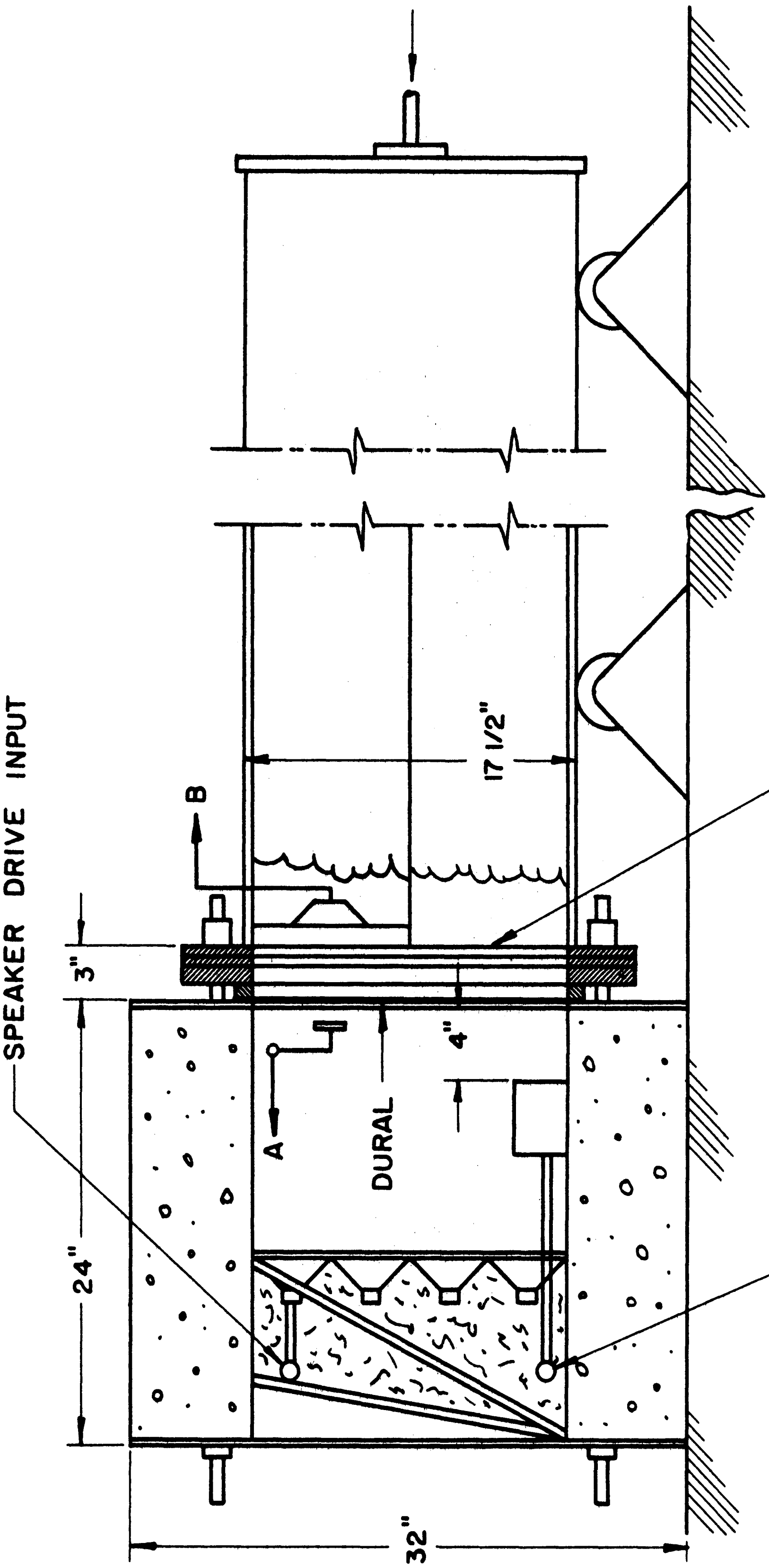


FIGURE I. AIRCRAFT TRANSMISSION-LOSS TEST APPARATUS

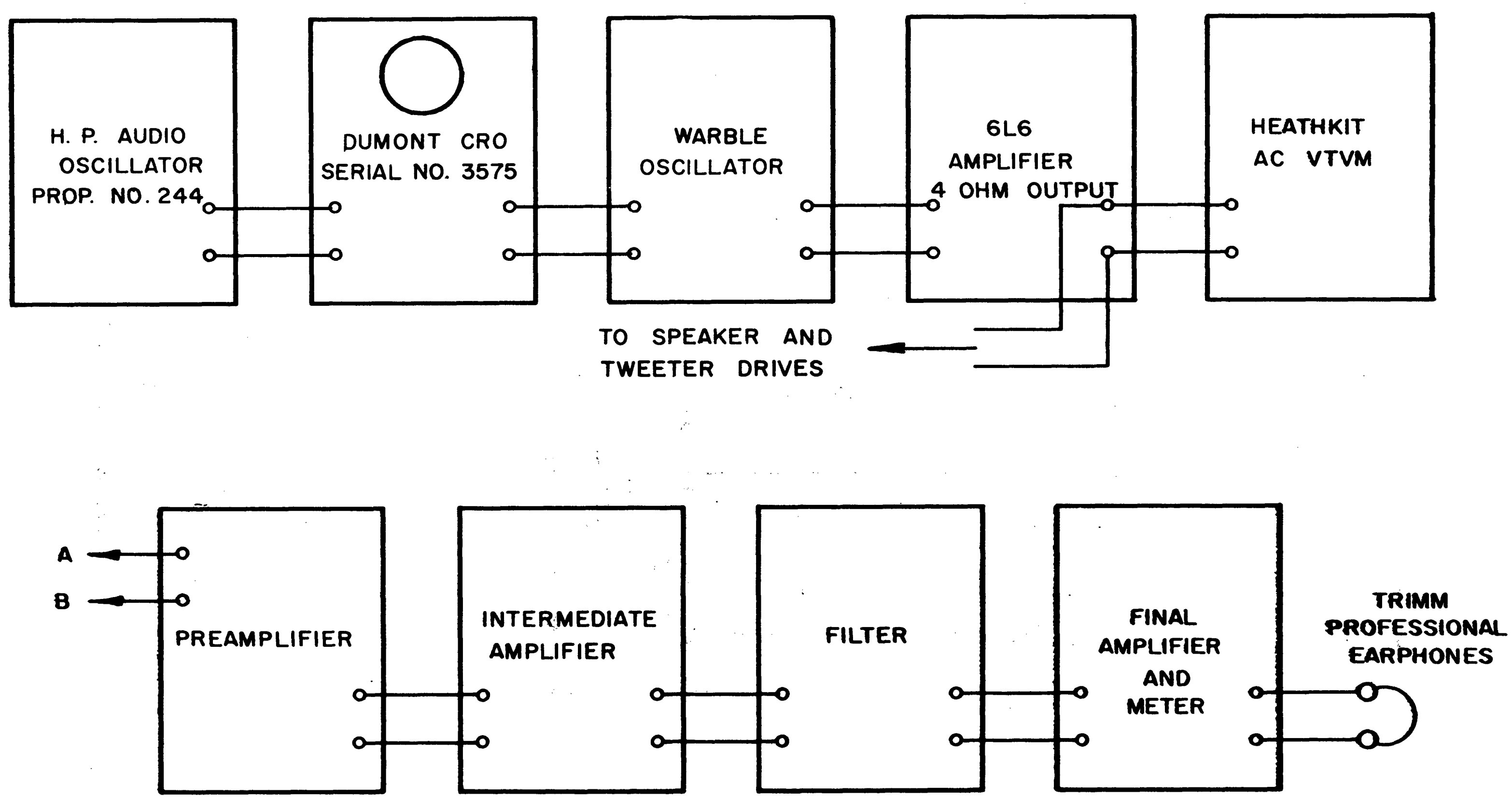
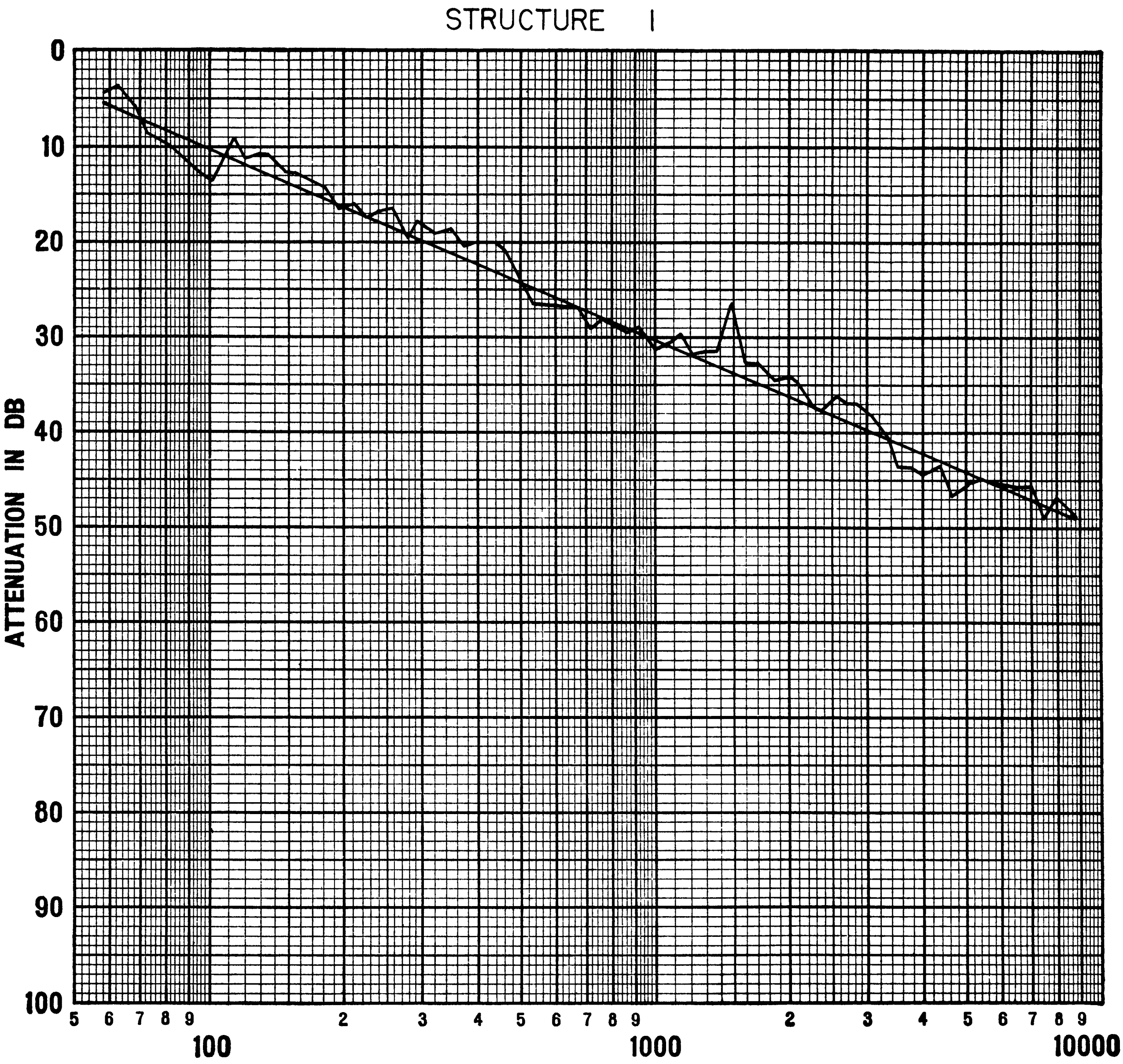
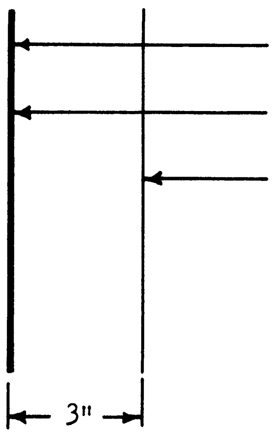


FIGURE 2. INSTRUMENTATION FOR AIRCRAFT TRANSMISSION-LOSS TEST APPARATUS

SOUND TRANSMISSION CURVE





0.020" Dural	0.2800 lb/ft^2
Tape (1 Layer)	0.1144
Trim	0.0441
Treatment Weight	0.1585

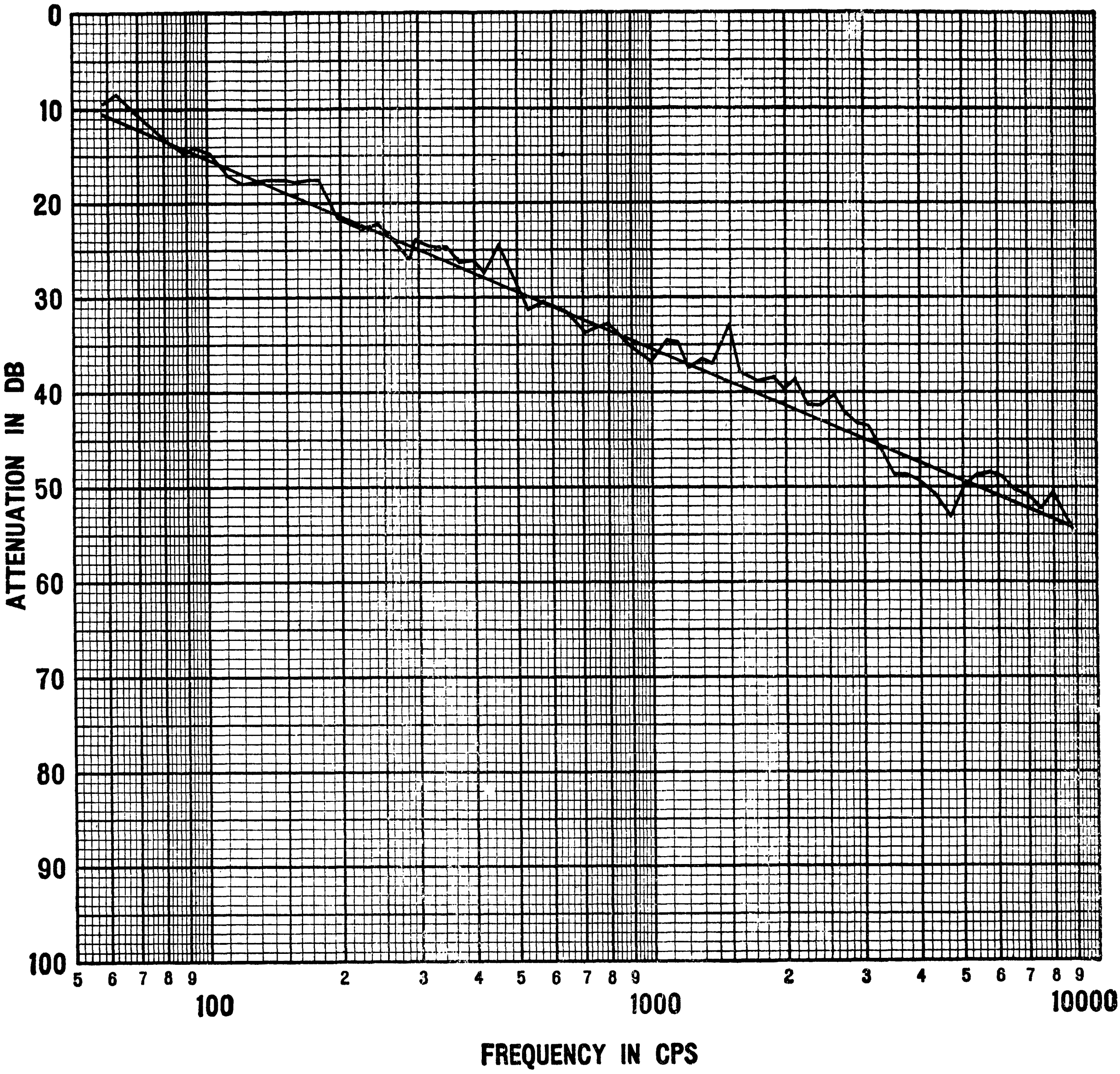
Average Attenuation, 2890-8800 cps = 44.4
Average Attenuation, 1830-5400 cps = 40.0

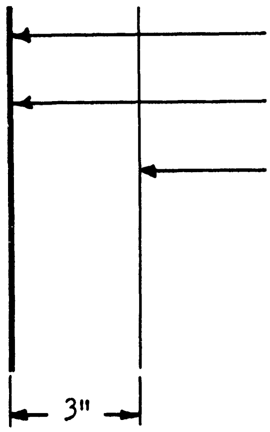
Merit Factor = 1.89
Q Factor = 2.21

FIGURE 3

SOUND TRANSMISSION CURVE

STRUCTURE 2





0.020" Dural	0.2800 lb/ft^2
Tape (4 Layers)	0.4578
Trim	0.0441
Treatment Weight	0.5019

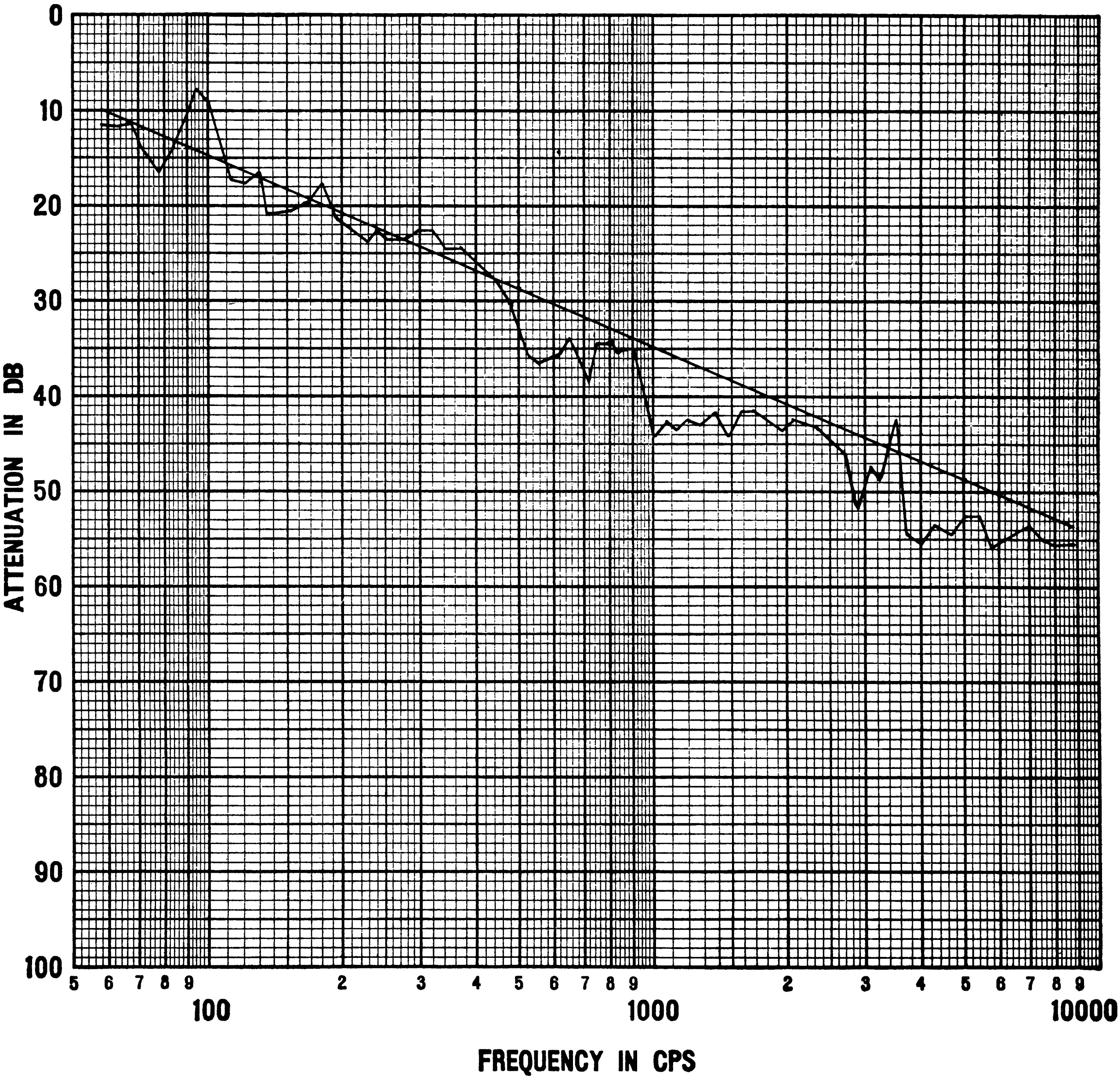
Average attenuation, 2890-8800 cps = 49.4
Average Attenuation, 1830-5400 cps = 45.1

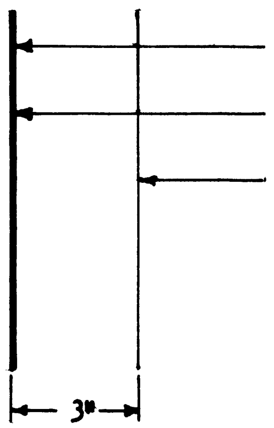
Merit Factor = 0.56
Q Factor = 0.84

FIGURE 4

SOUND TRANSMISSION CURVE

STRUCTURE 3





0.020" Dural	0.2800 lb/ft^2
Tape, Minn. Mining (4 Layers)	0.4253
Trim	0.0419
Treatment Weight	0.4672

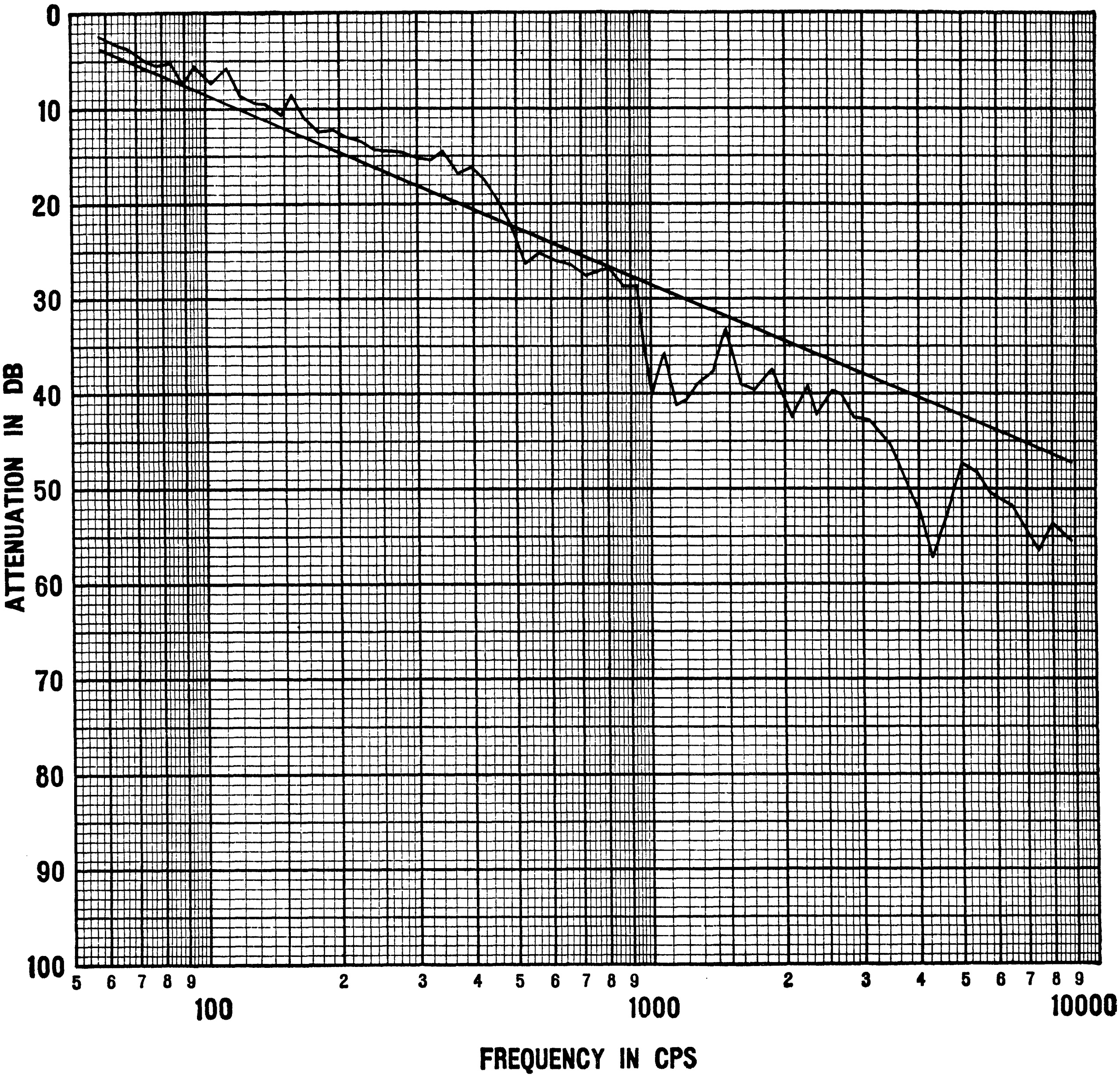
Average Attenuation, 2890-8800 cps = 52.8
Average Attenuation, 1830-5400 cps = 48.1

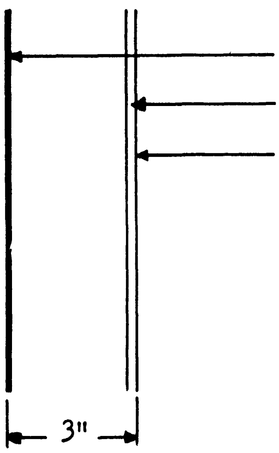
Merit Factor = 8.78
Q Factor = 8.13

FIGURE 5

SOUND TRANSMISSION CURVE

STRUCTURE 4





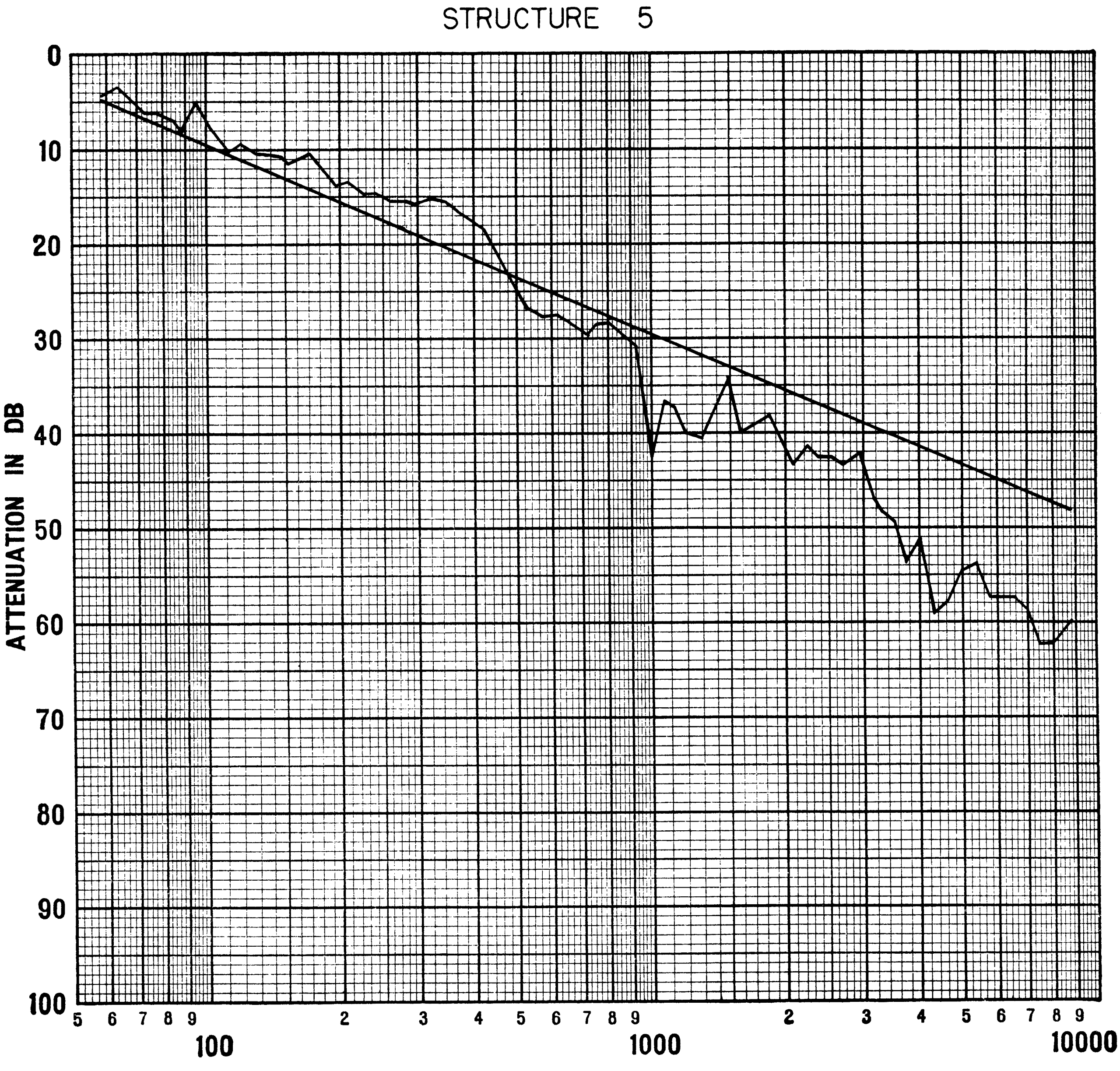
0.020" Dural	0.2800 lb/ft^2
1/8" Polyurethane	0.0375
Trim	0.0441
Treatment Weight	0.0816

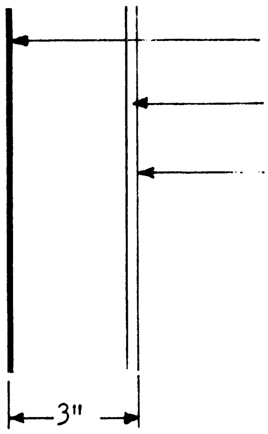
Average Attenuation, 2890-8800 cps = 50.3
Average Attenuation, 1830-5400 Cps = 44.8

Merit Factor = 96.3
Q Factor = 84.1

FIGURE 6

SOUND TRANSMISSION CURVE





0.020" Dural	0.2800 lb/ ft^2
5/16" Polyurethane	0.0741
Trim	0. 0441
Treatment Weight	0.1182

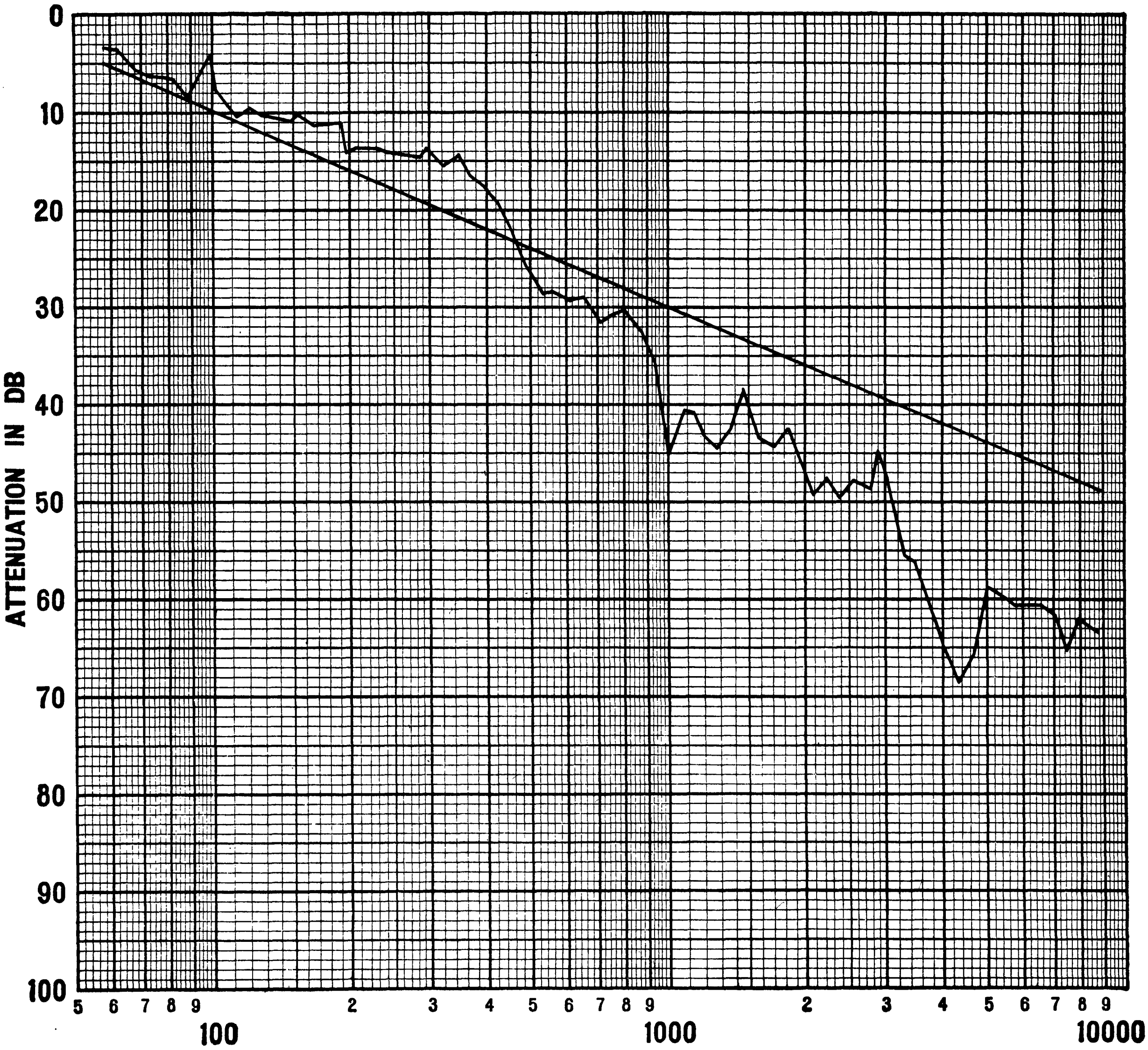
Average Attenuation, 2890-8800 cps = 54.8
Average Attenuation, 1830-5400 cps = 47.6

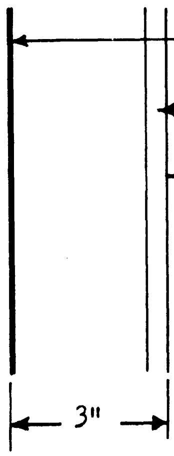
Merit Factor = 97.4
Q Factor = 73.7

FIGURE 7

SOUND TRANSMISSION CURVE

STRUCTURE 6





0.020" Dural	0.2800 lb/ft^2
3/8" Polyurethane	0.0976
Trim	0.0441
Treatment Weight	0.1417

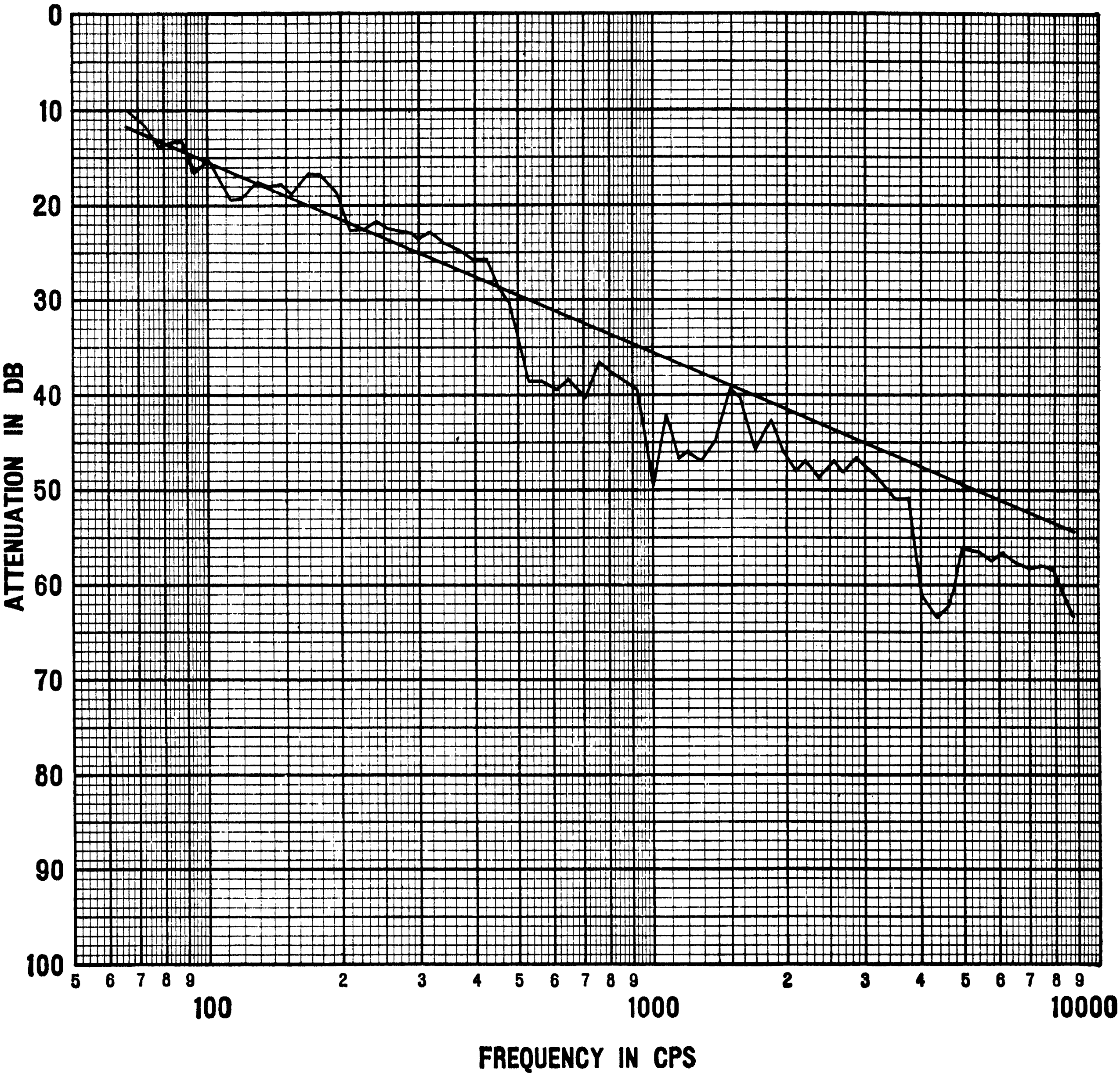
Average Attenuation, 2890-8800 cps = 59.8
Average Attenuation, 1830-5400 cps = 53.8

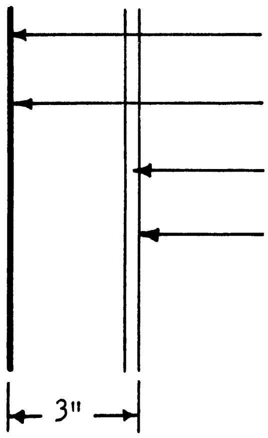
Merit Factor = 113
Q Factor = 102

FIGURE 8

SOUND TRANSMISSION CURVE

STRUCTURE 7





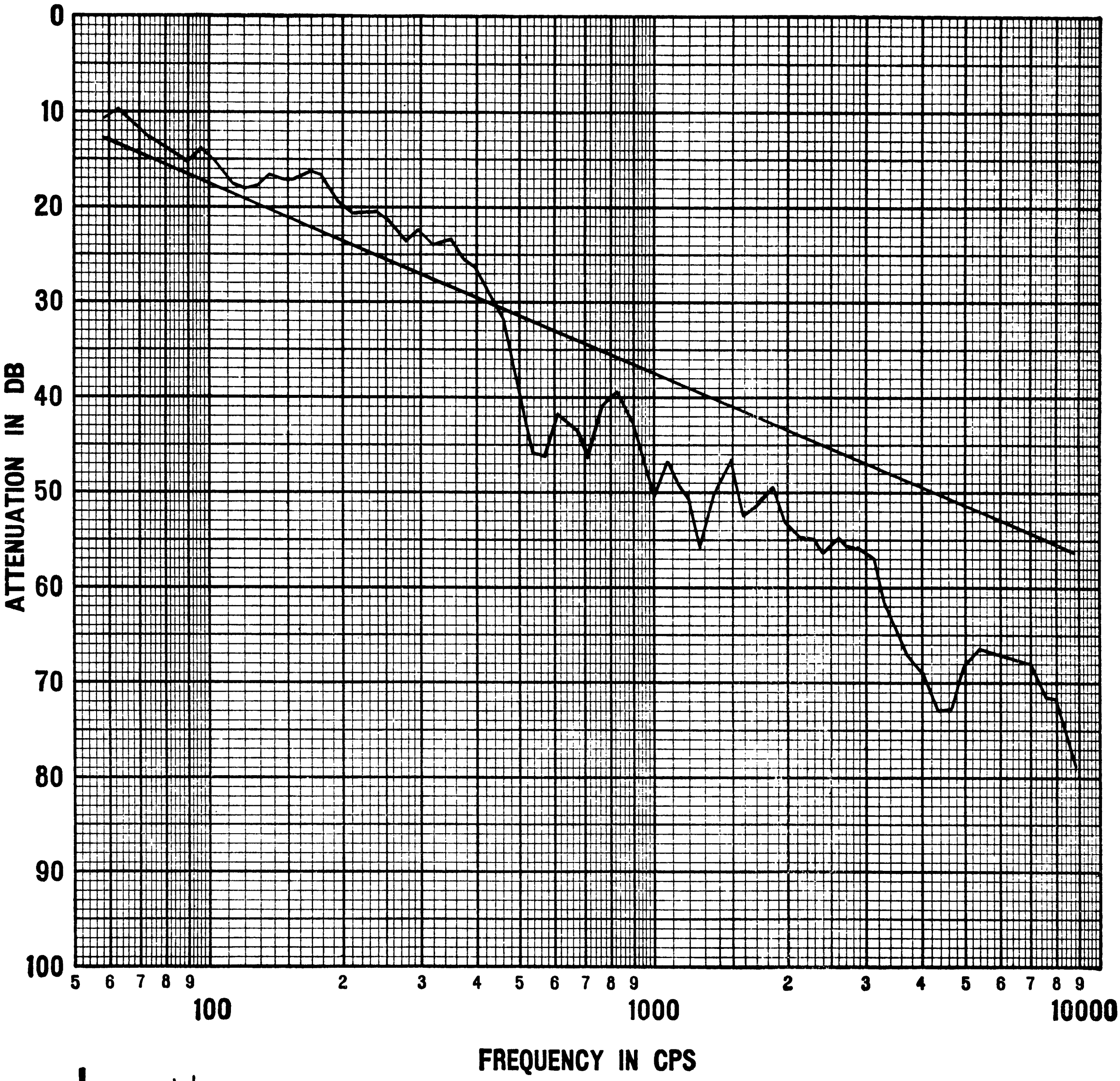
0.020" Dural	0.2800 lb/ft^2	
Tape (4 Layers)	0.4578	Merit Factor = 12.8 Q Factor = 11.9
1/8" Polyurethane	0.0375	
Trim	0.0441	
Treatment Weight	0.5394	

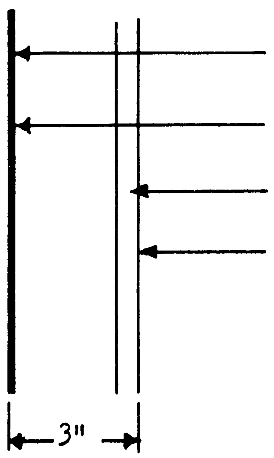
Average Attenuation, 2890-8800 cps = 56.4
Average Attenuation, 1830-5400 cps = 51.5

FIGURE 9

SOUND TRANSMISSION CURVE

STRUCTURE 8





0.020" Dural	0.2800 lb/ft^2
Tape (4 Layers)	0.4578
3/8" Polyurethane	0.0976
Trim	0.0441
Treatment Weight	0.5995

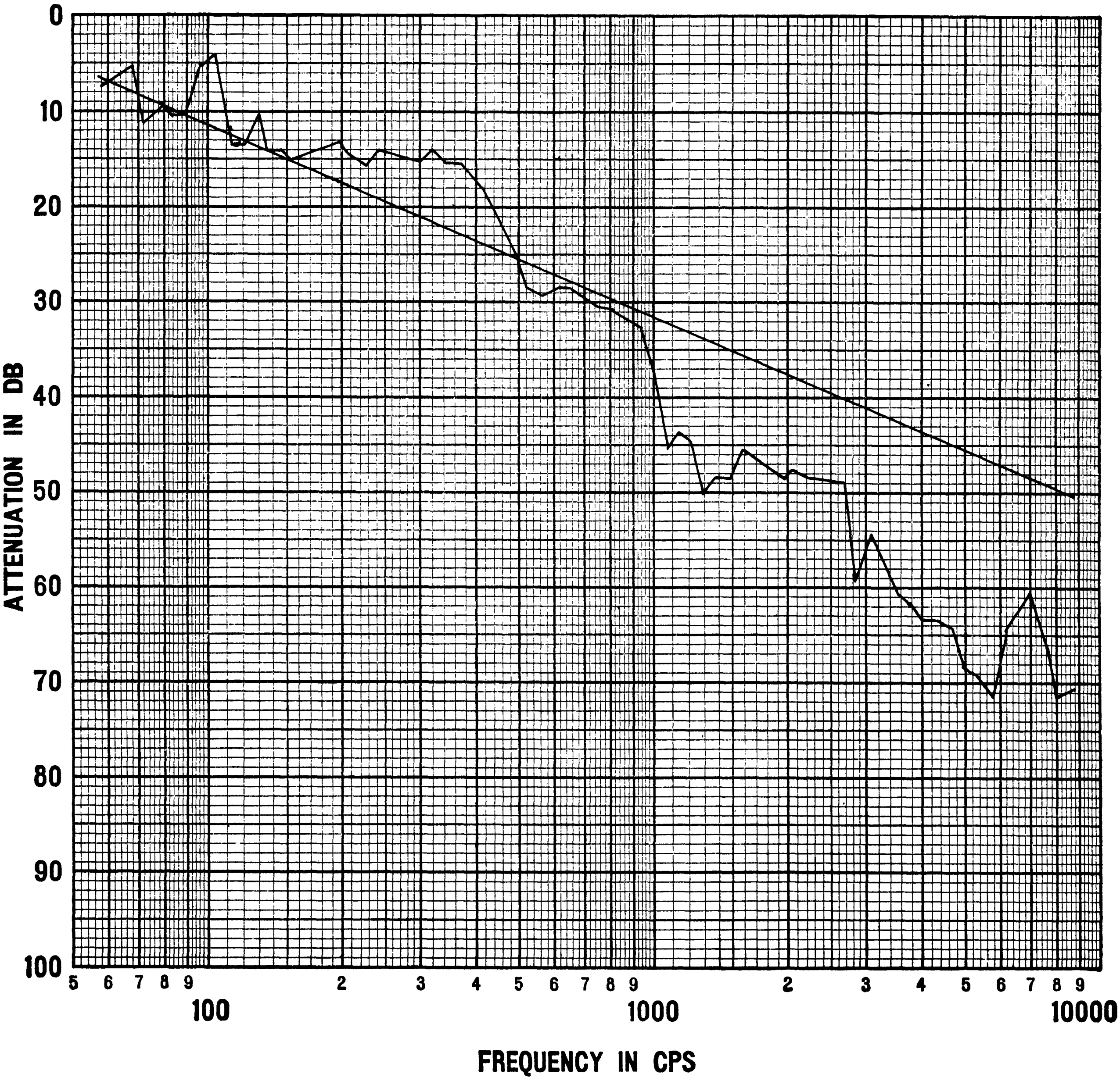
Merit Factor = 29.2
Q Factor = 25.4

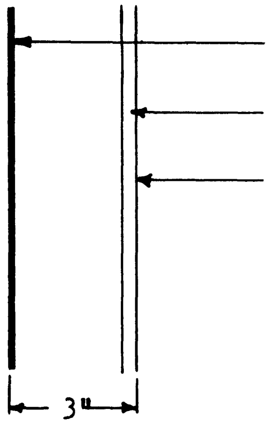
Average Attenuation, 2890-8800 cps = 67.7
Average Attenuation, 1830-5400 cps = 60.9

FIGURE 10

SOUND TRANSMISSION CURVE

STRUCTURE 9





0.020" Dural	0.2800 lb/ft^2
3/8" Blanket (-9388)	0.1887
Trim	0.0419
Treatment Weight	0.2306

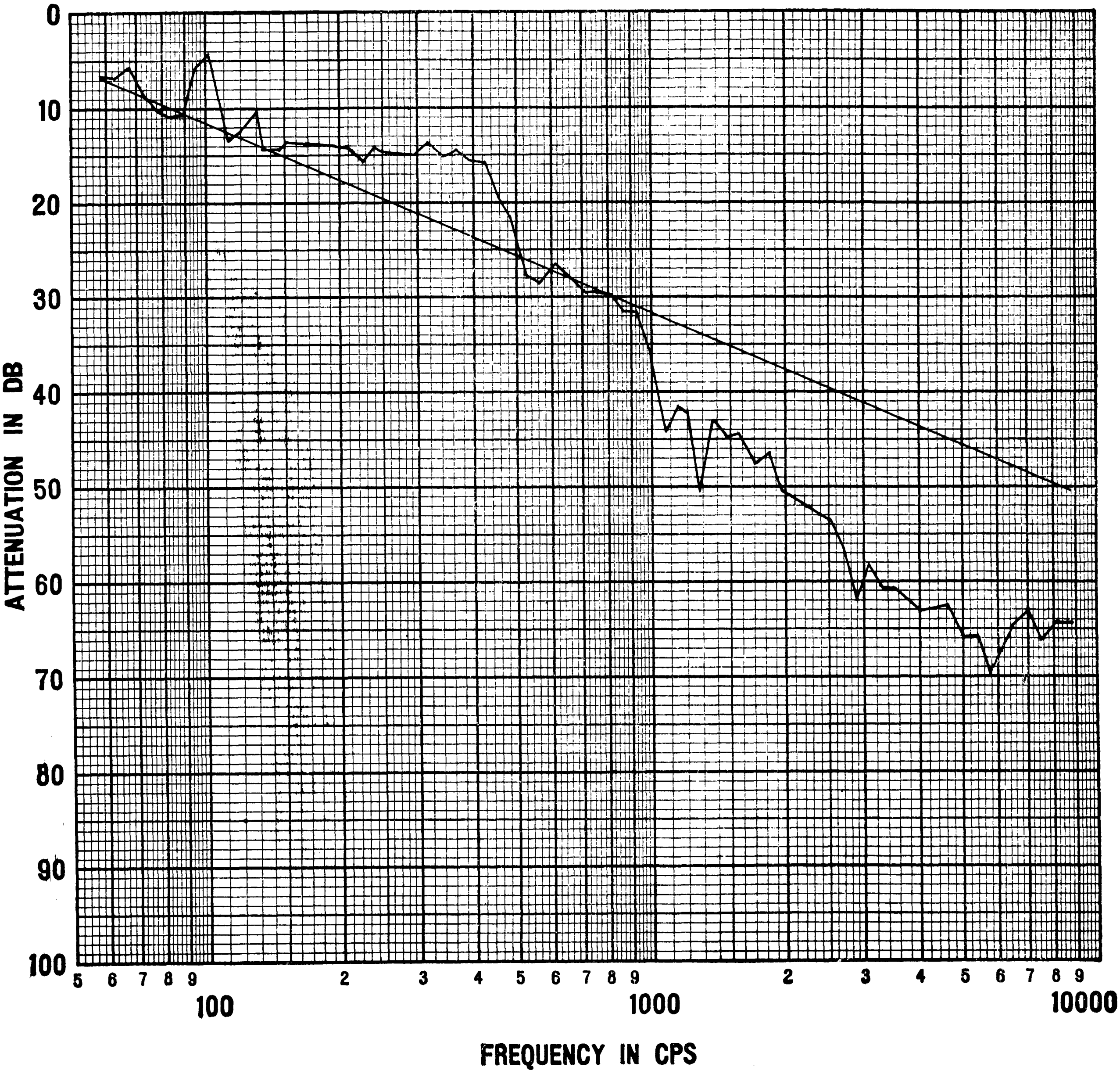
Average Attenuation, 2890-8800 cps = 64.2
Average Attenuation, 1830-5400 cps = 56.6

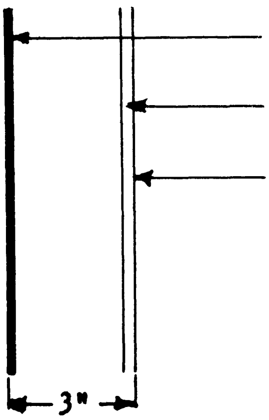
Merit Factor = 81.5
Q Factor = 67.6

FIGURE 11

SOUND TRANSMISSION CURVE

STRUCTURE 10





0.020" Dural	0.2800 lb/ft^2
1/4" Blanket (-1179)	0.2038
Trim	0.0419
Treatment Weight	0.2457

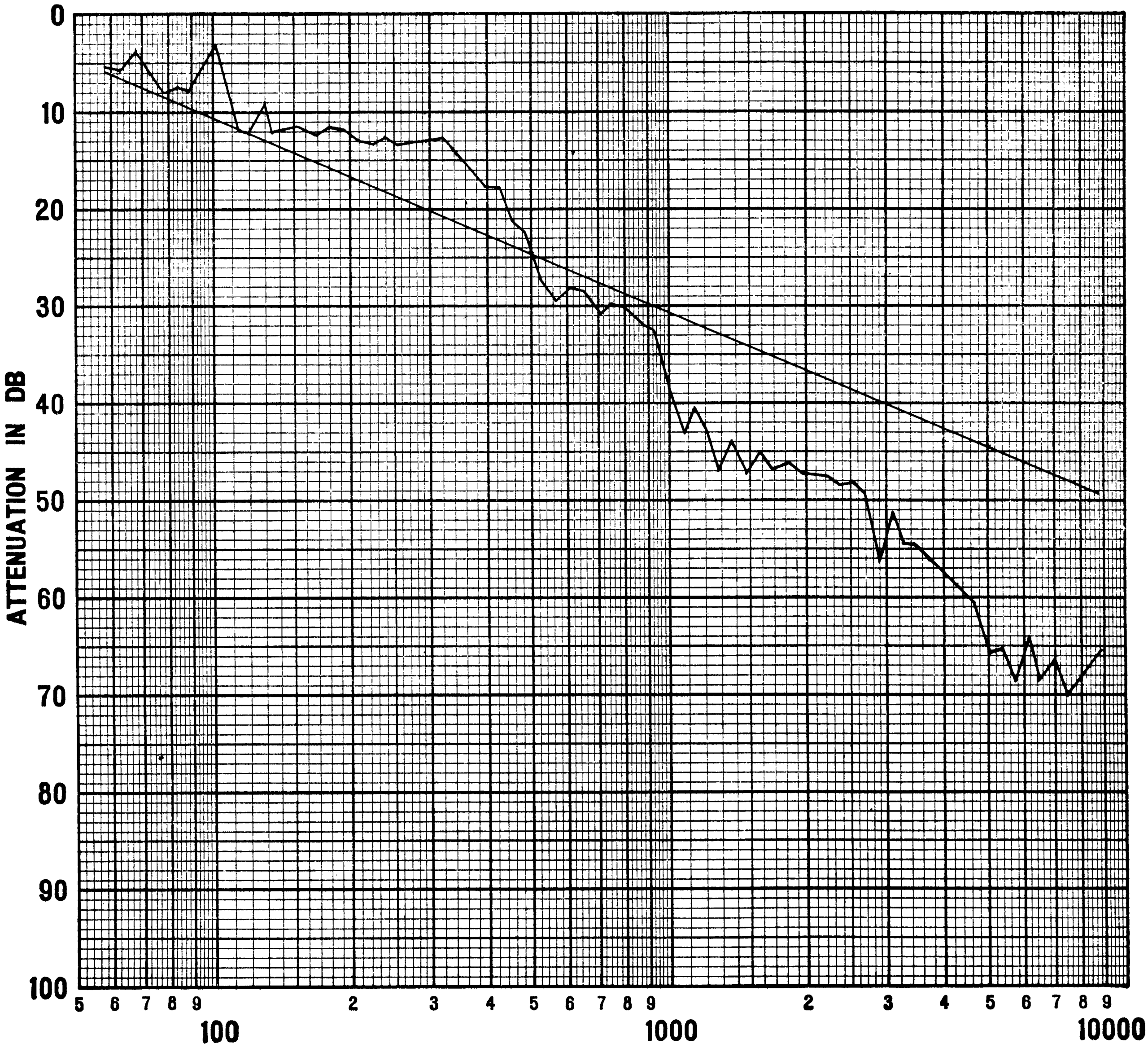
Average Attenuation, 2890-8800 cps = 63.7
Average Attenuation, 1830-5400 cps = 58.0

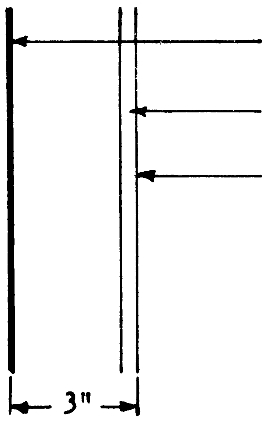
Merit Factor = 73.3
Q Factor = 68.4

FIGURE 12

SOUND TRANSMISSION CURVE

STRUCTURE 11





0.020" Dural	0.2800 lb/ft^2
1/4" Blanket (-1049)	0.1373
Trim	0.0419
Treatment Weight	0.1792

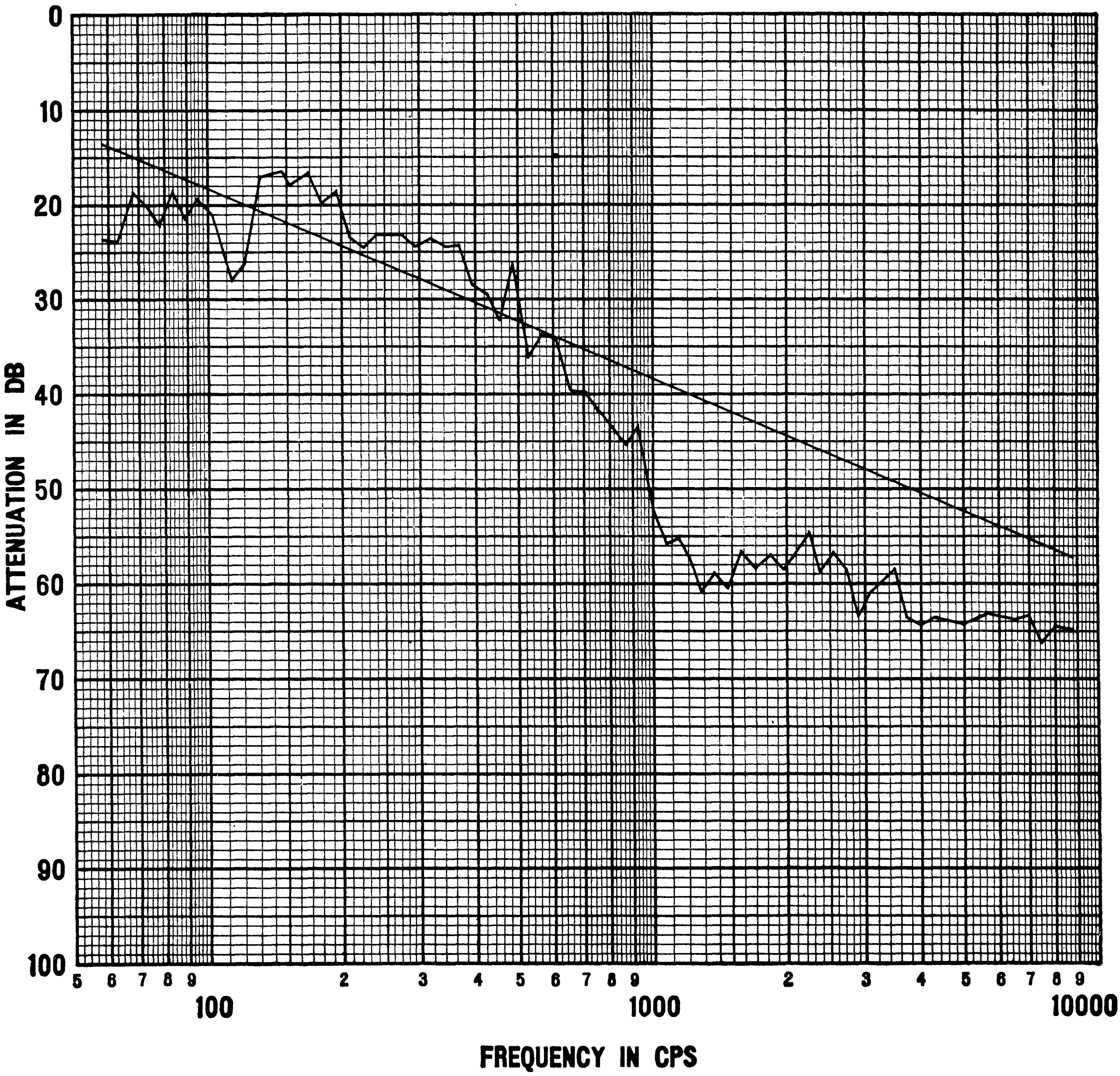
Average Attenuation, 2890-8800 cps = 61.9
Average Attenuation, 1830-5400 cps = 53.9

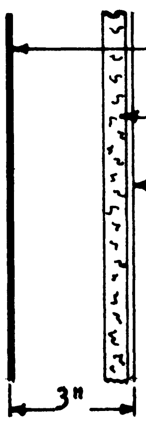
Merit Factor = 97.1
Q Factor = 77.0

FIGURE 13

SOUND TRANSMISSION CURVE

STRUCTURE 12





0.020" Dural	0.2800 lb/ft^2
3/8" Honeycomb, 0.016 skin	0.790
Trim	0.0419
Treatment Weight	0.8319

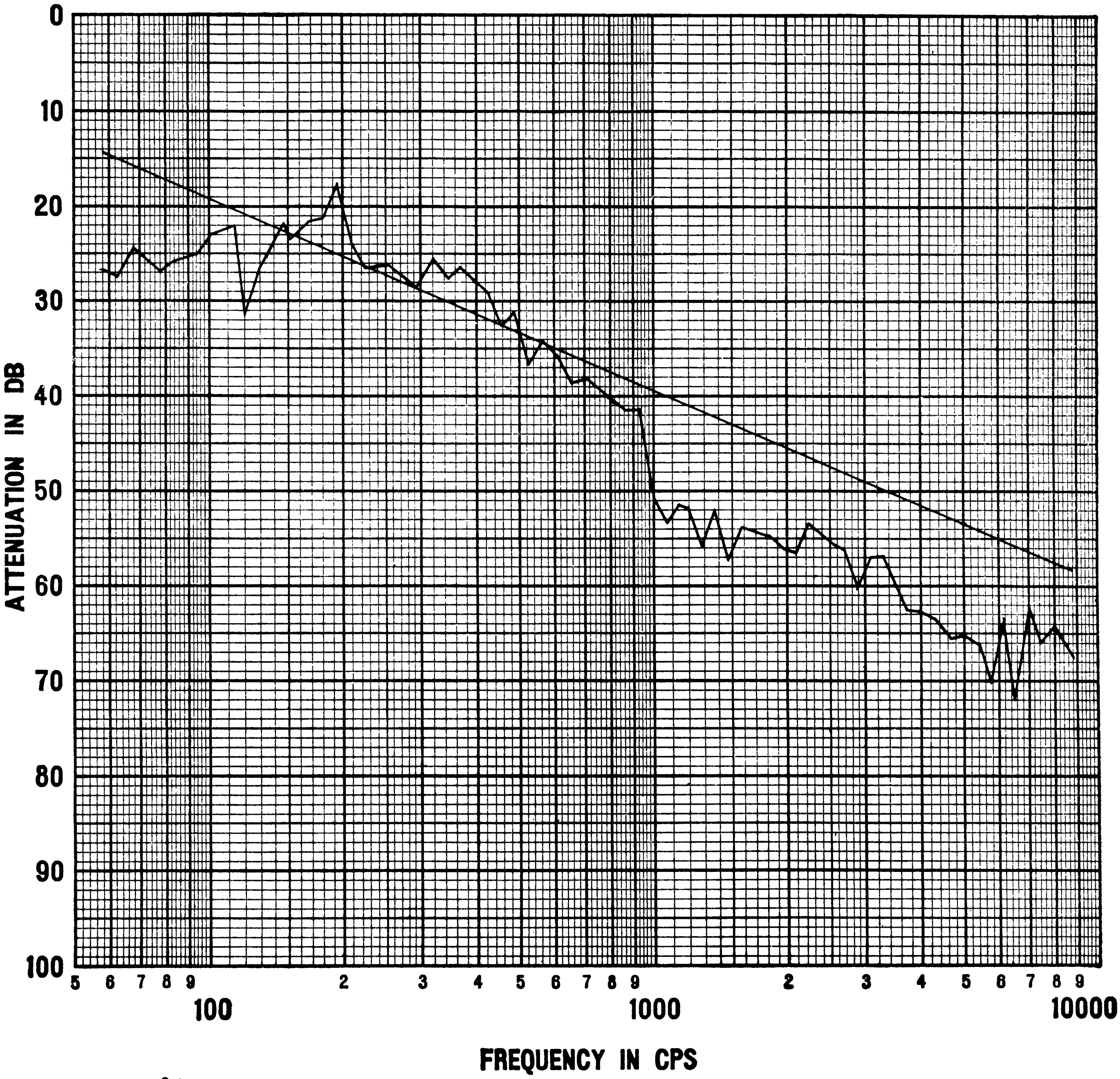
Average Attenuation, 2890-8800 cps = 63.2
Average Attenuation, 1830-5400 cps = 60.4

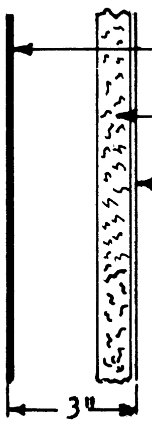
Merit Factor = 13.2
Q Factor = 15.3

FIGURE 14

SOUND TRANSMISSION CURVE

STRUCTURE 13





0.020" Dural	0.2800 lb/ft^2
1/2" Honeycomb, 0.016" skin	0.930
Trim	0.0419
Treatment Weight	0.9719

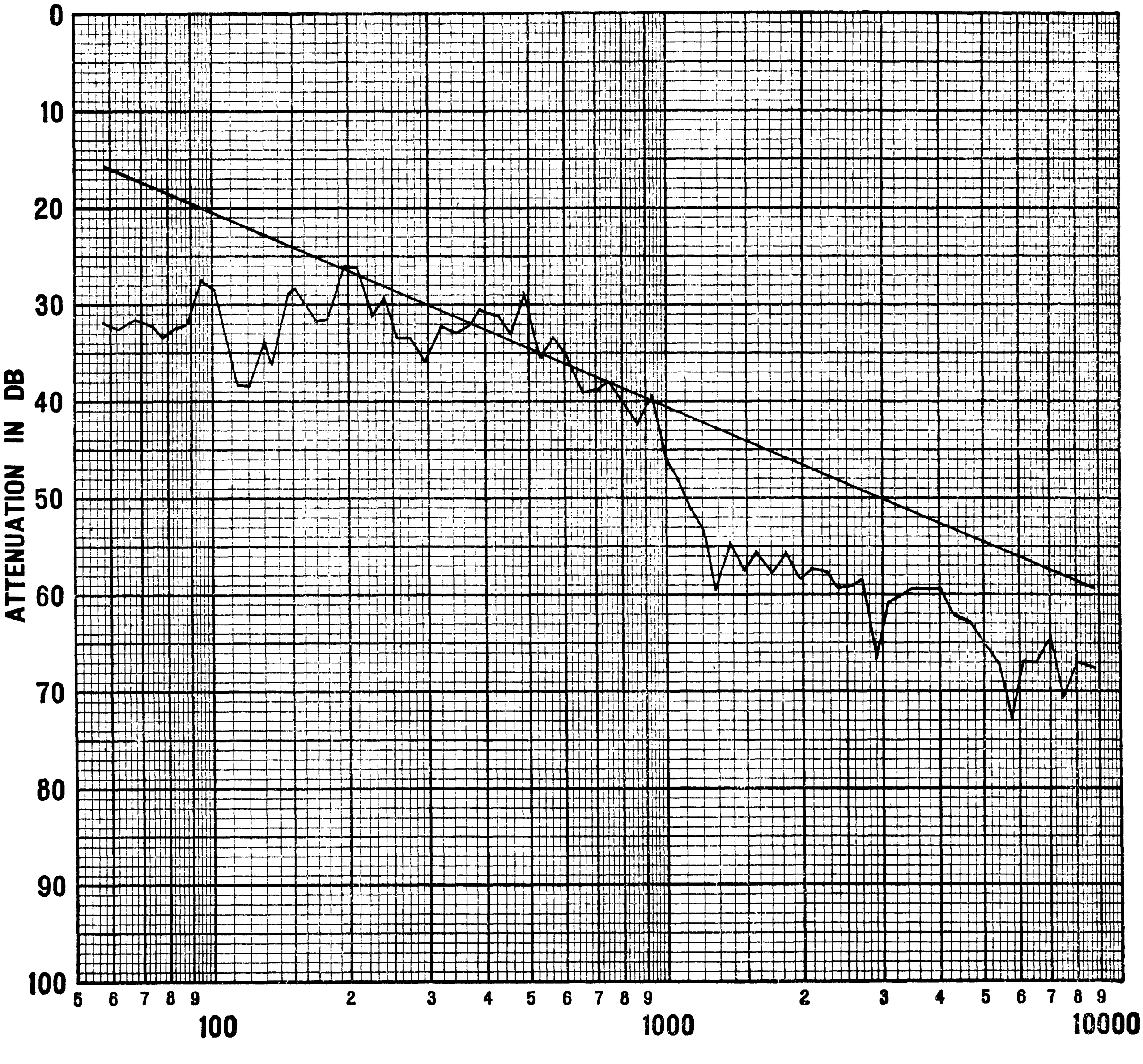
Average Attenuation, 2890-8800 cps = 63.8
Average Attenuation, 1830-5400 cps = 59.3

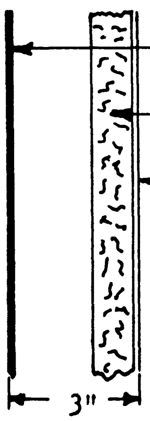
Merit Factor = 10.9
Q Factor = 11.0

FIGURE 15

SOUND TRANSMISSION CURVE

STRUCTURE 14





0.020" Dural	0.2800 lb/ft^2
1" Honeycomb, 0.016" skin	1.180
Trim	0.0419
Treatment Weight	1.2219

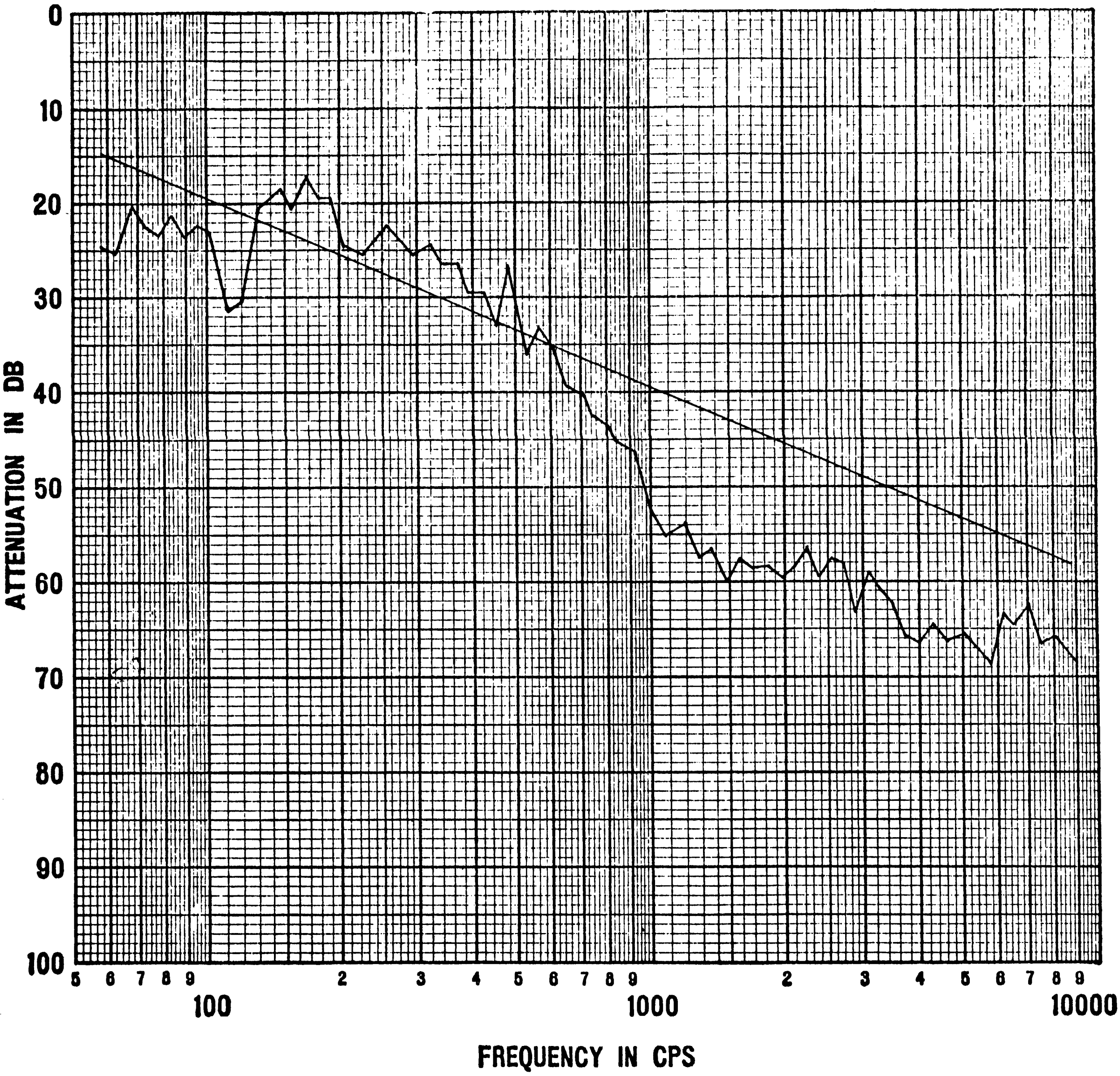
Average Attenuation, 2890-8800 cps = 64.6
Average Attenuation, 1830-5400 cps = 60.5

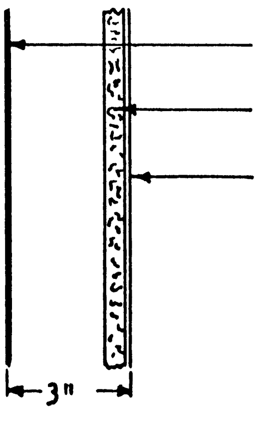
Merit Factor = 8.02
Q Factor = 8.35

FIGURE 16

SOUND TRANSMISSION CURVE

STRUCTURE 15





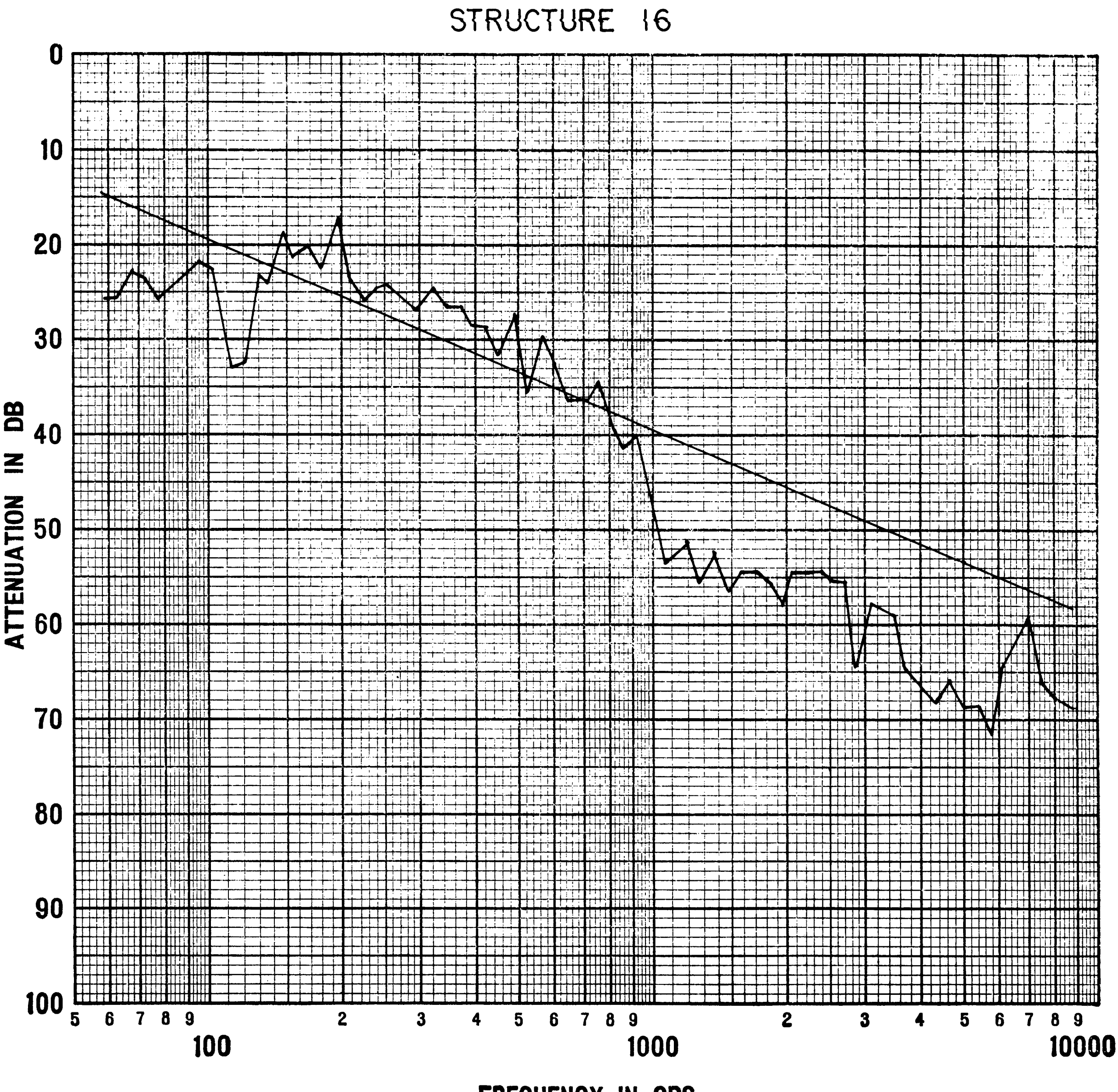
0.020" Dural	0.2800 lb/ft^2
3/8" Honeycomb, 0.020 skin	0.955
Trim	0.0419
Treatment Weight	0.9969

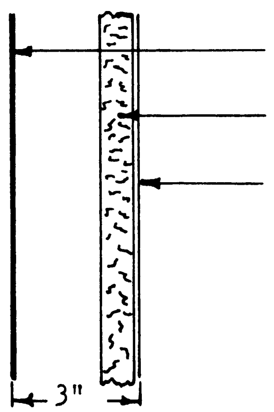
Average Attenuation, 2890-8800 cps = 64.8
Average Attenuation, 1830-5400 cps = 61.7

Merit Factor = 11.4
Q Factor = 12.8

FIGURE 17

SOUND TRANSMISSION CURVE





0.020" Dural	0.2800 lb/ft^2
1/2" Honeycomb, 0.020" skin	0.968
Trim	0.0419
Treatment Weight	1.0099

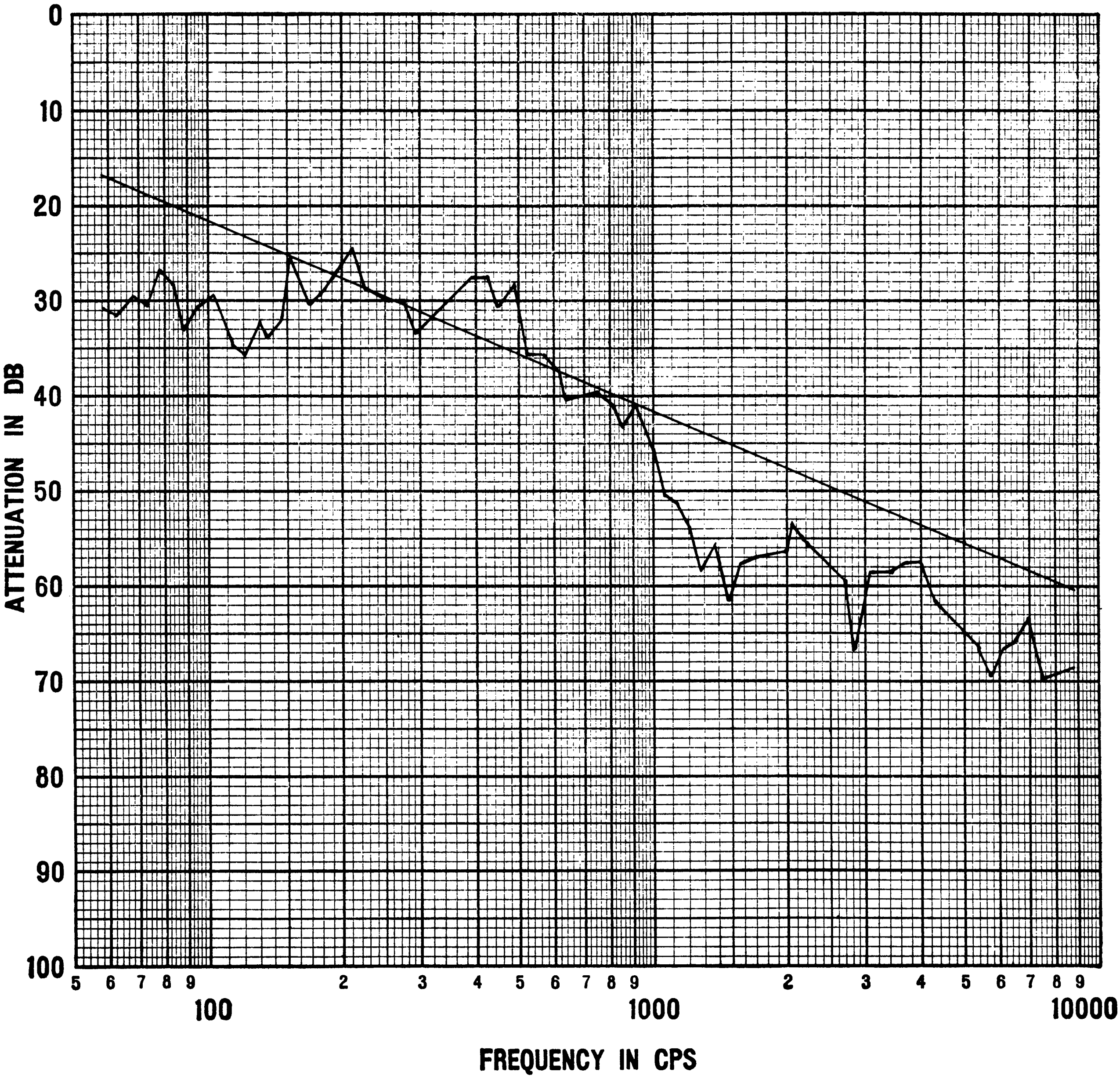
Average Attenuation, 2890-8800 cps = 64.7
Average Attenuation, 1830-5400 cps = 60.6

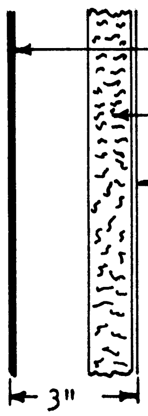
Merit Factor = 11.2
Q Factor = 11.5

FIGURE 18

SOUND TRANSMISSION CURVE

STRUCTURE 17





0.020" Dural	0.2800 lb/ft^2
1" Honeycomb, 0.020" skin	1.268
Trim	0.0419
Treatment Weight	1.3099

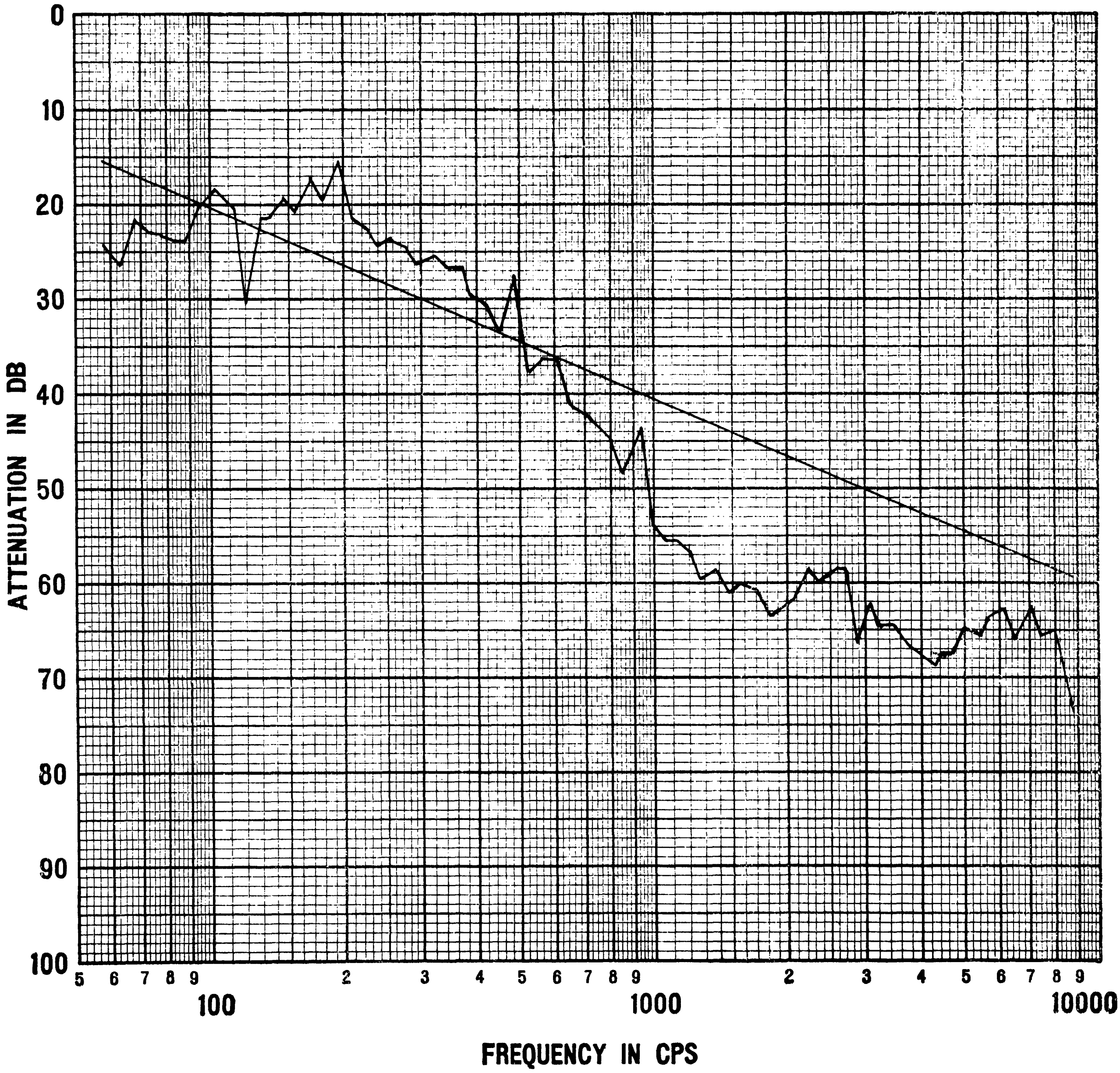
Average Attenuation, 2890-8800 cps = 63.9
Average Attenuation, 1830-5400 cps = 59.5

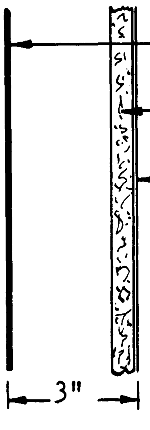
Merit Factor = 6.57
Q Factor = 6.64

FIGURE 19

SOUND TRANSMISSION CURVE

STRUCTURE 18





0.020" Dural 0.2800 lb/ft²

3/8" Honeycomb, 0.025" skin 1.112

Trim 0.0419

Treatment Weight 1.1539

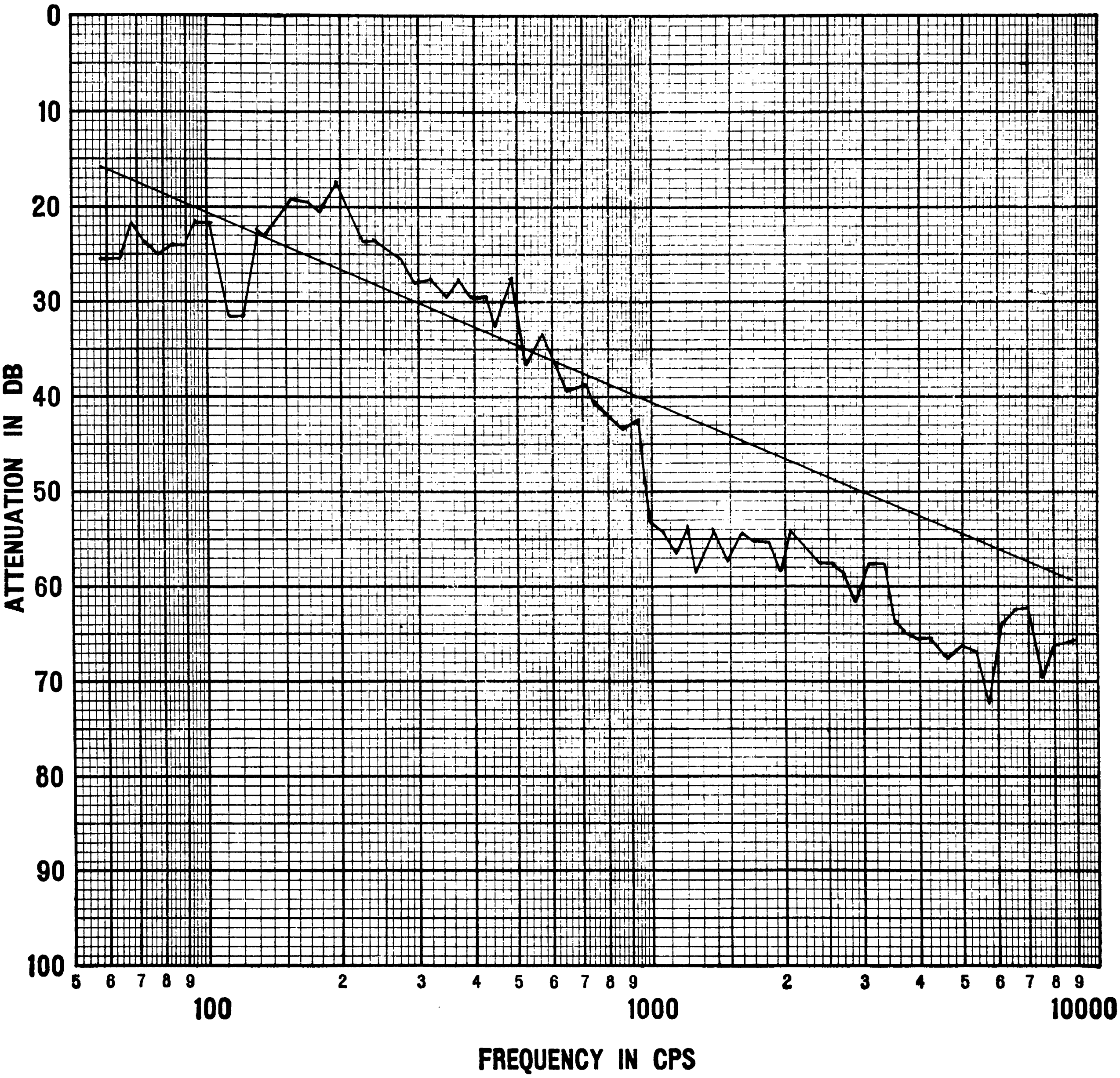
Average Attenuation, 2890-8800 cps = 65.7
Average Attenuation, 1830-5400 cps = 63.6

Merit Factor = 9.79
Q Factor = 11.9

FIGURE 20

SOUND TRANSMISSION CURVE

STRUCTURE 19



0.020" Dural	0.2800 lb/ft^2
1/2" Honeycomb, 0.025" skin	1.140
Trim	0.0419
Treatment Weight	1.1819

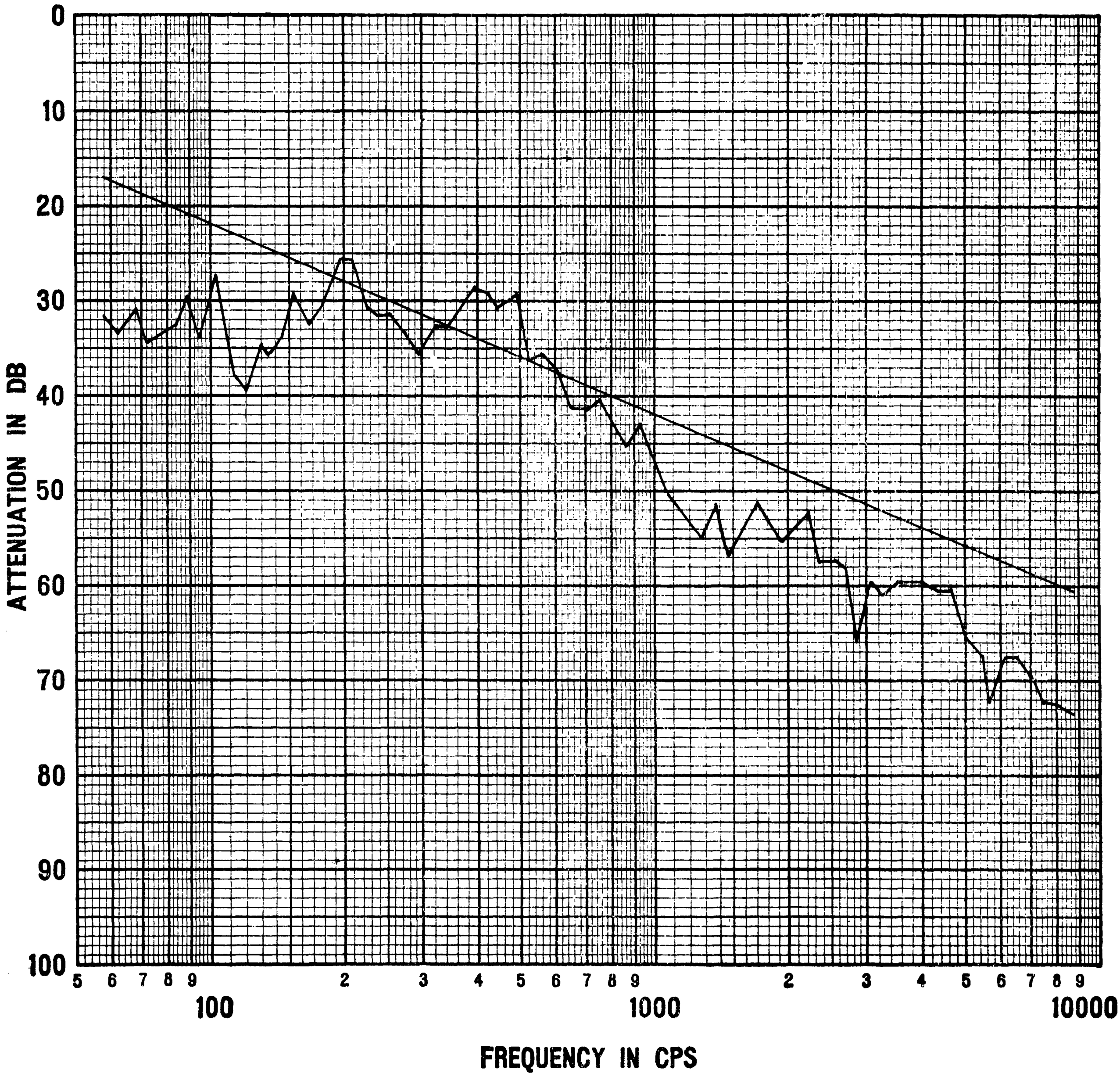
Average Attenuation, 2890-8800 cps = 64.7
Average Attenuation, 1830-5400 cps = 60.9

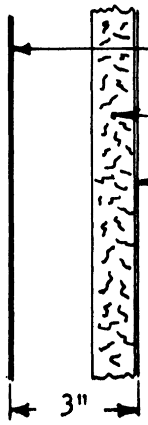
Merit Factor 8.38
Q Factor 8.97

FIGURE 21

SOUND TRANSMISSION CURVE

STRUCTURE 20





0.020" Dural	0.2800 lb/ft^2
1" Honeycomb, 0.025" skin	1.390
Trim	0.0419
Treatment Weight	1.4319

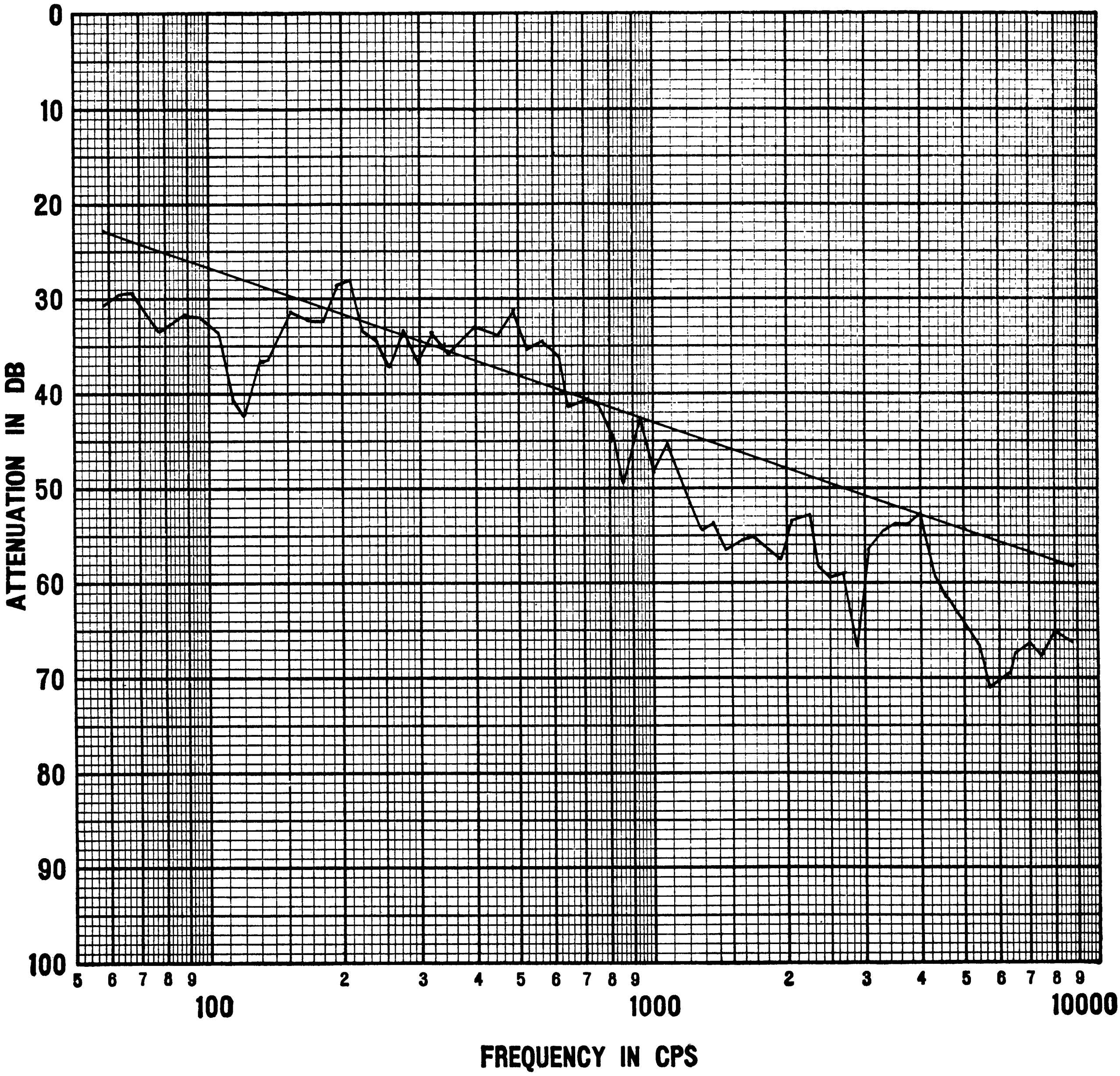
Average Attenuation, 2890-8800 cps = 64.5
Average Attenuation, 1830-5400 cps = 59.3

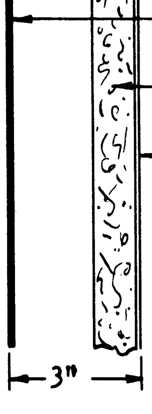
Merit Factor = 6.01
Q Factor = 5.45

FIGURE 22

SOUND TRANSMISSION CURVE

STRUCTURE 21





0.020" Dural	0.2800 lb/ft^2
1" Honeycomb, 0.016" skin	1.095
Trim	0.0419
Treatment Weight	1.1369

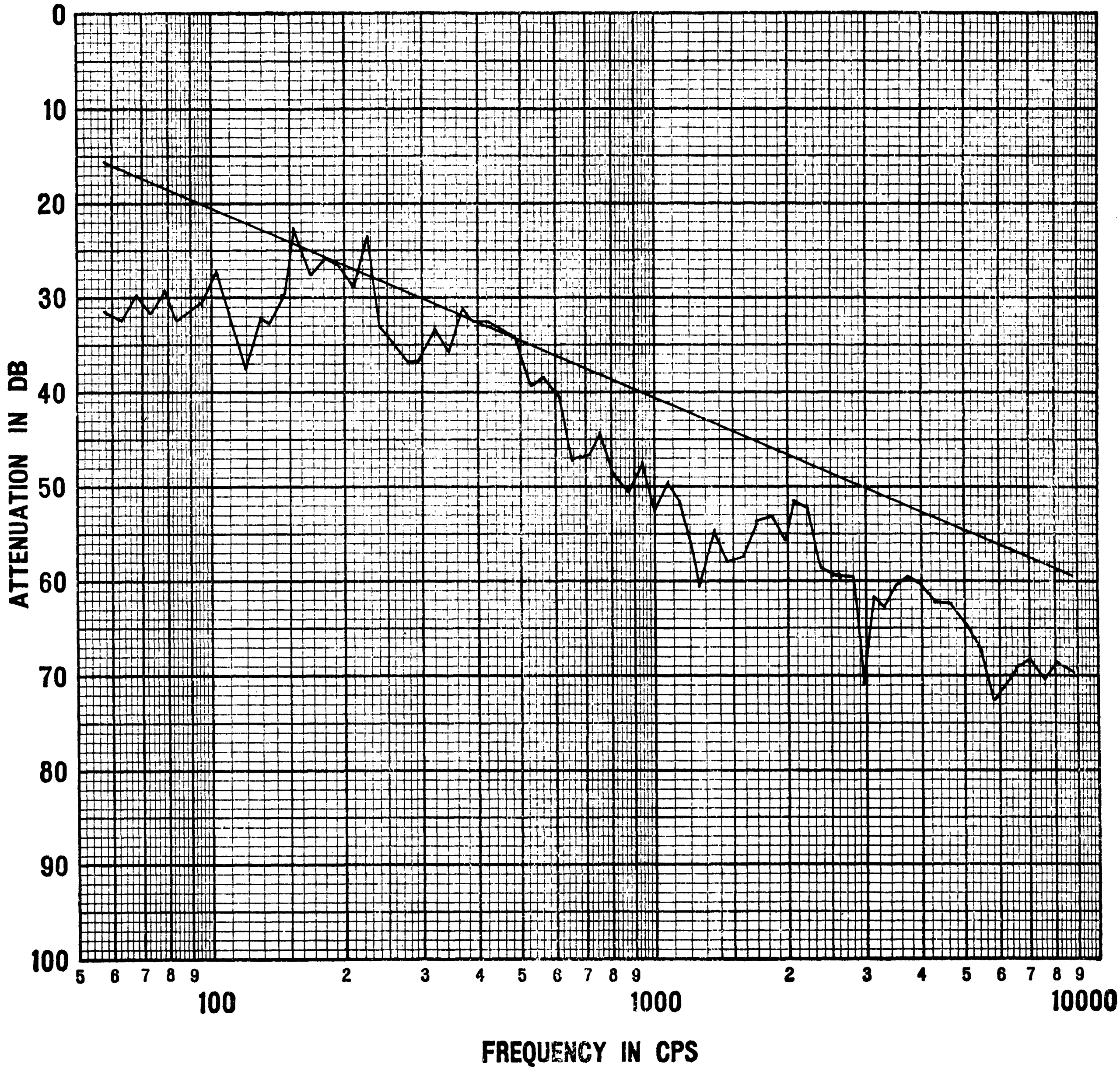
Average Attenuation, 2890-8800 cps = 62.5
Average Attenuation, 1830-5400 cps = 58.0

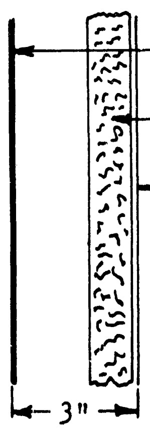
Merit Factor = 7.21
Q Factor = 7.21

FIGURE 23

SOUND TRANSMISSION CURVE

STRUCTURE 22





0.020" Dural	0.2800 lb/ft^2
1" Honeycomb, 0.020" skin	1.188
Trim	0.0419
Treatment Weight	1.2299

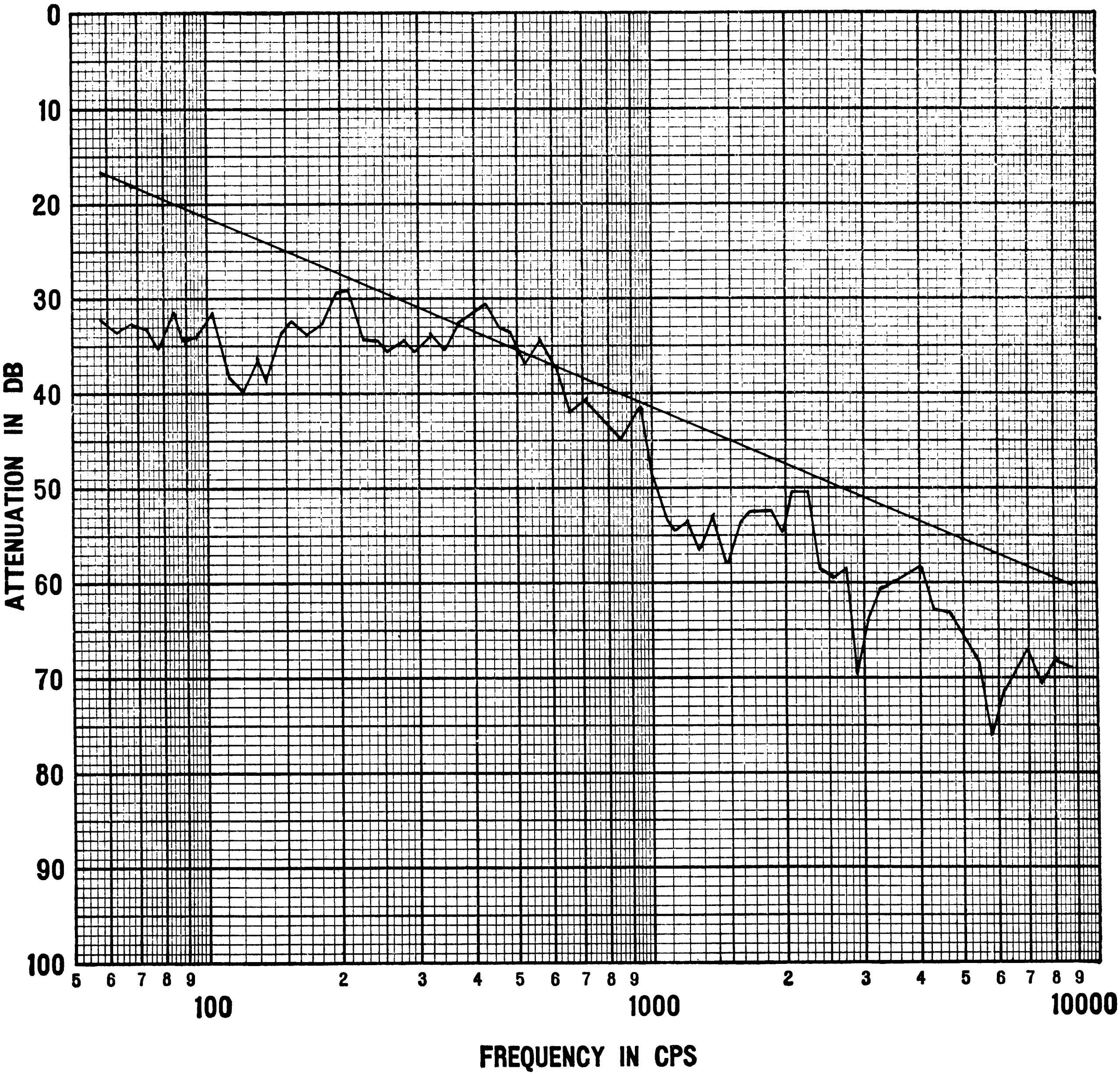
Average Attenuation, 2890-8800 cps = 66.0
Average Attenuation, 1830-5400 cps = 60.1

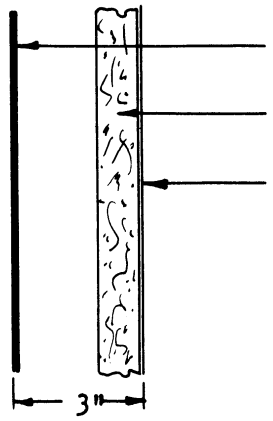
Merit Factor = 7.42
Q Factor = 6.42

FIGURE 24

SOUND TRANSMISSION CURVE

STRUCTURE 23





0.020" Dural	0.2800 lb/ft^2
1" Honeycomb, 0.025" skin	1.305
Trim	0.0419
Treatment Weight	1.3469

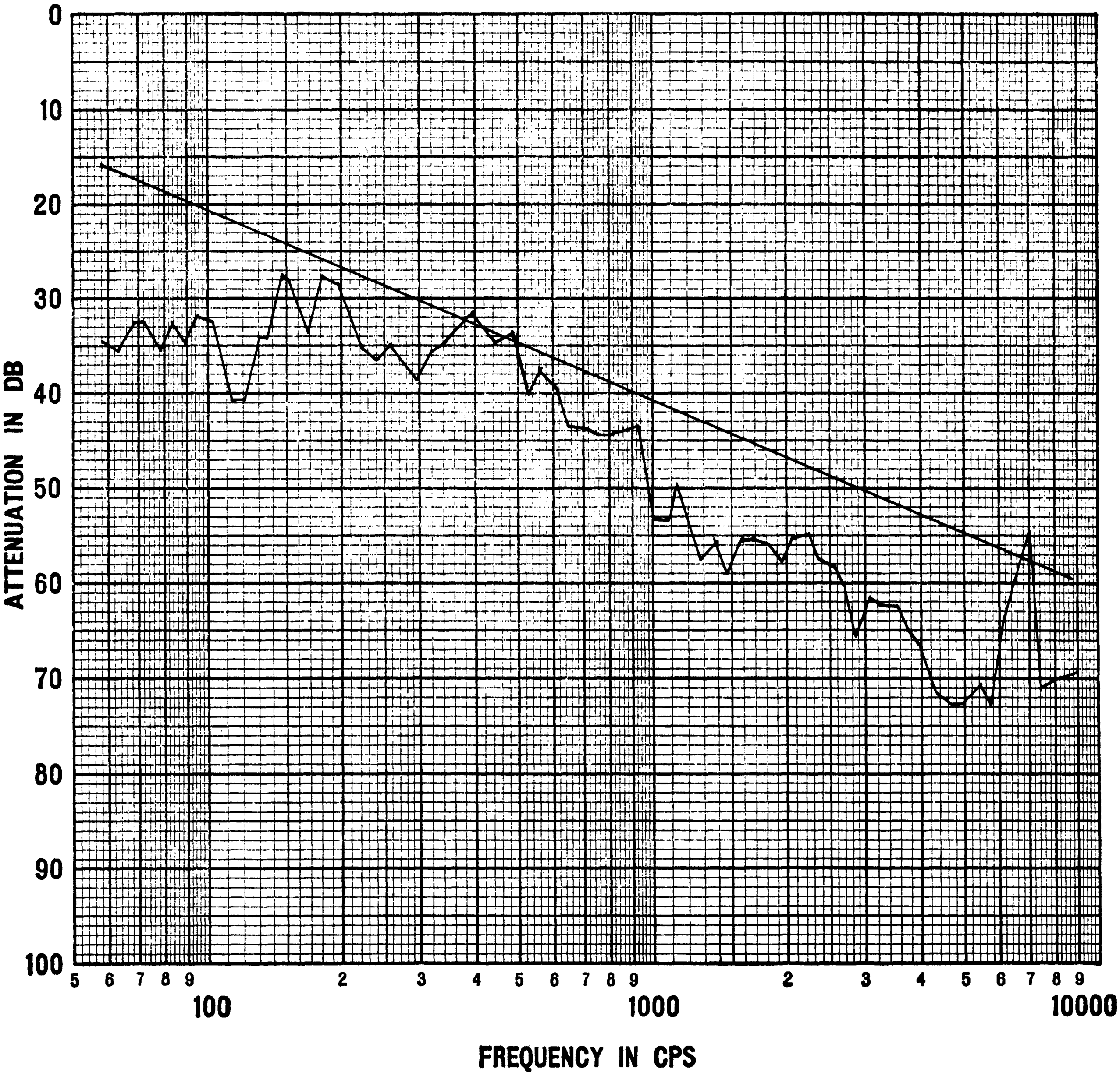
Average Attenuation, 2890-8800 cps = 66.1
Average Attenuation, 1830-5400 cps = 59.8

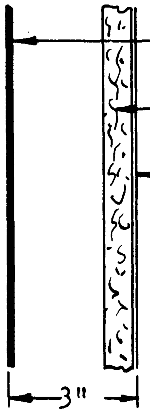
Merit Factor = 7.87
Q Factor = 6.46

FIGURE 25

SOUND TRANSMISSION CURVE

STRUCTURE 24





0.020" Dural	0.2800 lb/ft^2
1/2" Honeycomb, metal	1.1950
Trim	0.0419
Treatment Weight	1.2369

Average Attenuation, 2890-8800 cps = 66.6
Average Attenuation, 1830-5400 cps = 62.9

Merit Factor = 9.46
Q Factor = 10.0

FIGURE 26