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INVESTIGATION OF KORFUND DAMPING MATERIALS FOR SONAR DOME WINDO--ETC(U)
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UNCLASSIFIED USL-TM-2133-257-69 NL

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U. S. Navy Underwater Sound Laboratory
Fort Trumbull, New London, Connecticut

INVESTIGATION OF KORFUND DAMPING MATERIALS FOR SONAR DOME WINDOWS

by

Howard N. Phelps, Jr

USL Technical Memorandum No. 2133-257-69

17 April 1969

USL-TM-2133-257-69

INTRODUCTION

This technical memorandum presents the progress made in investigating certain vibration damping materials manufactured by the Korfund Dynamics Corporation, Westbury, Long Island, New York. The purpose of the investigation is to find an acoustically-transparent damping material for windows of sonar domes in general, and for the AN/SQS-26 steel sonar dome in particular.

DESCRIPTION OF DAMPING MATERIALS

The formulations of the various materials have not been obtained, since they are proprietary to the Korfund Dynamics Corporation.

Six 30" x 30" x 0.250" HY-80 steel plates, one curved steel plate, and an AN/SQS-26 sonar dome section were coated with various damping materials and combinations of damping materials by the Korfund Dynamics Corporation. Each flat plate was coated on one side by trowelling; the insides of the curved plate and the AN/SQS-26 sonar dome section were sprayed. The total thickness of the damping material(s) applied to each test specimen was 0.5 inch.

Table I presents the test specimen numbers and descriptions, along with the identifications of the respective 0.5-inch coatings of damping materials. Other data utilized in this memorandum were obtained from reference (a).

TABLE I

Plate No.	Plate Dimensions	Thickness of Damping Material (s)	Type(s) of Damping Material(s)
113A	30" x 30" x 0.250"	0.5"	80-2K-WRA
114	30" x 30" x 0.250"	0.5"	Urethane
142	30" x 30" x 0.250"	0.5"	$\frac{1}{4}$" of 80A & $\frac{1}{4}$" of 80-2K-WR
143	30" x 30" x 0.250"	0.5"	80-2K-WR
144	30" x 30" x 0.250"	0.5"	$\frac{1}{2}$" of 80A & Sealant
145	30" x 30" x 0.250"	0.5"	80A
177	48" H by 18.5" R Curved	0.5"	80-2K-WR
193R	4' x 4' AN/SQS-26 Sonar dome section	0.5"	80-2K-WR

Vibrodamper Type 80A

Vibrodamper Compound Type 80A is a general purpose vibration damping compound for application at room temperature, which is formulated to give optimum damping for noise control when applied to metal panels; this material is of a vista green color. The maximum thickness of the wet material that can be applied to a vertical plane surface is 3/16 inch; when the material's wet density is 1.5 gm/cm^3 and its dry density is 1.3 gm/cm^3. The thermal conductivity factor (K) is 0.175 BTU/hr/ft^2/F/ft; its curing time is 48 hours at room temperature, and approximately 30 minutes at 250°F. The maximum safe drying temperature is 380°F; the minimum drying temperature is 50°F. The total solids content is 63%. The material is resistant to dilute acids, alkalis, greases, gasoline, and aliphatic oils. It has a very long life; is unaffected by sunlight or ozone; and does not become brittle or change, in any way, with age. Maximum damping occurs at 80°F.

The material may be applied directly to any metal, provided the metal is free of grease and oil. A primer coat is recommended on all metals, except galvanized sheet metal. It is best applied by spraying, but it can be trowelled on easily. For spraying, a spray gun similar to a DeVilbiss Spray Gun No. P-MBC-565, with a nozzle I.D. of $\frac{1}{4}$ inch and with supply through a 3/4 inch I.D. pipe from a pressure pot of 25 psi, is recommended. Line air pressure should be 35 to 40 psi. Curing time is 48 hours at room temperature, or approximately 30 minutes at 250°F for a 1/8 inch thick coating, which is about the maximum thickness that can be sprayed on in one coat.

Type 80A provides damping in the temperature range from 50°F through 160°F and is non-flammable.

Vibrodamper Type 80-2K-WR

Vibrodamper Compound Type 80-2K-WR has a vista green color and has a thermal conductivity factor (K) of 0.9 BTU/hr/ft^2/°F/inch, which can be varied according to specific requirement. This material should never be applied at a temperature below 50°F. Curing starts when the two parts, A and B, are mixed; the curing reaction is exothermic. Application of thin coats will keep the curing reaction temperature low, and, as a result, the material will set slowly. The material starts to harden after one-half hour, but eight hours at room temperature are required for complete curing. The material is fire-retardant and is self-extinguishing per ASTM D-635-56T. It has resistance against water, salt water spray, oil, acids, and alkalis. Its electrical resistivity is excellent, exceeding 1 x 10^6 ohm-cm; it has good aging characteristics. No noticeable change in damping characteristics occurs after initial cure; maximum damping occurs at 80°F. The Type 80-2K-WRA compound is the low-temperature material; its adhesion to all metals is excellent. The material may be applied either by trowelling or by spraying.

Application by trowelling is accomplished as follows:

1. Clean metal surfaces thoroughly (steel surfaces should be sandblasted or wire brushed).

2. Mix 1 part by weight of 80-2K-WR Part A with 1 part by weight of 80-2K-WR Part B until a uniform green color is obtained. (Before curing, the working life of the mixture will vary according to the quantity of material mixed in one operation, as follows: 2 lbs cures in 2 hours; 10 lbs in 45 minutes; and 20 lbs in 25 minutes. Working life can be extended by spreading the mix in a shallow pan.) Do not mix more than 20 lbs in one batch.

3. Use power mixing equipment for batches weighing more than 2 lbs to ensure a proper mix.

4. Apply with a trowel. (Four pounds of material will cover one square foot with a thickness of ½ inch.) Never apply at temperatures below 50°F.

5. Allow 8 hours at room temperature for complete curing.

6. Clean all tools (trowels, mixers, etc.) with Toluol or similar solvent immediately after use.

Application by spraying is accomplished as follows:

1. Mix 10 lbs of 80-2K-WR Part A with 10 lbs of 80-2K-WR Part B mechanically, using a portable dough mixer or similar equipment, until a uniform green color is obtained.

2. Empty into a regular 5-gallon pail, or jacketed water-cooled container of same approximate capacity.

3. Begin preparation of another 20-lb batch in mixer.

4. Spray, using a pump type unit (10:1 ratio) which can be lifted easily and dropped into successive 5-gallon containers of 80-2K-WR. Use a 3/4-inch I.D. feed line and a 1/4-inch round nozzled gun, DeVilbiss Gun No. P-MBC-565, or equivalent. Atomizing pressure is 40 to 50 psi.

5. Commence spraying immediately after filling of the 5-gallon pail, since the 20 lbs of 80-2K-WR will tend to harden within 20 to 30 minutes. A jacketed water-cooled container will allow an appreciably long pot life in warm weather.

6. After the contents of one pail have been used, switch the pump unit into the next freshly-prepared container of 80-2K-WR and continue spraying. Four pounds of 80-2K-WR will cover one square foot with a thickness of $\frac{1}{2}$ inch.

7. Avoid mixing or applying the material in direct sunlight, since the presence of heat will reduce the working life of the mixture.

8. Never mix more 80-2K-WR than can be used within 20 minutes.

9. Avoid excessive skin contact with material and wash hands, etc., with soap and water after handling.

10. Allow 8 hours before newly treated metal is put into service.

DAMPING TESTS

Setup

The instrumentation setup and experimental procedure used for the damping measurements were similar to those descirbed in reference (b). Instrumentation was calibrated by the method described in reference (c).

Damping Characteristics

Figures 1 through 4 present the percent of critical damping versus 1/3 octave band center frequency for panels #142, #143, #144, and #145, respectively; these panels were coated on one side with a 1/2 inch thickness of damping material. For the frequency range from 2 kHz to 8 kHz: the panel coated with 1/4 inch of 80A plus 1/4 inch of 80-2K-WR (Figure 1) has approximately 3.0 %C/Cc to 4.3 %C/Cc; the panel coated with a 1/2 inch thickness of 80-2K-WR (Figure 2) has from 3.0 %C/Cc to 7.0 %C/Cc; the panel coated with a 1/2 inch thickness of 80A (Figure 3) has from 1.6 %C/Cc to 3.3 %C/Cc; and, the panel coated with a 1/2 inch thickness of 80A with a sealant (Figure 4) has from 1.9 %C/Cc to 4.1 % C/Cc.

TRANSMISSION AND REFLECTIVITY MEASUREMENTS

Setup (Plates 142 - 145)

Acoustic transmission measurements were made on plates #142, #143, #144, and #145 by General Dynamics/Electronics, Rochester, New York, under USL Contract N140-N70024-1071 (with the test setup shown in Figure 5). In these measurements, a 2 millisecond acoustic pulse was produced at the output of the projector. The pulse was received at the standard hydrophone. This pulse is a function of the energy directly transmitted through the plate and also of the energy diffracted around the edge of the plate. The propagation delay time from the edge of the plate to the hydrophone is approximately 1.25 ft x (1 sec/5000 ft) or 250 microseconds (considering the shortest path around the plate). With the propagation time through the plate in the order of 200 microseconds, it is possible to gate out the last portion of the return and measure the first portion that is propagated directly through the plate. In order to provide maximum separation of the transmitted and diffracted energy, the standard hydrophone was mounted one inch away from the center of the plate.

All plates were washed with detergent to ensure wetting of the surface before tests; care was taken to ensure that trapped air bubbles were excluded from the surface.

Setup (Plate 113A, 114, 177, and 193R)

Acoustic transmission and reflection measurements were made on plates #113A, #114, #177, and #193R by Hazeltine Corporation's Electro-Acoustics Systems Laboratory, Braintree, Massachusetts, under USL Contract N70024-1226. The transmission level was measured with the test setup illustrated in Figure 6. In this particular test, the receiving hydrophone, Navy Standard M115B, was placed 3 inches directly behind the acoustic panel, and the sound source, Navy J-11, was positioned 5 feet to the front, at 0 degrees bearing. During these measurements, the projector-plate separation was varied up to 15 feet and no change was measured in the test results.

For the reflectivity measurement, the test setup was as shown in Figure 7. With the hydrophone at position A, the sound level was measured and recorded while the panel was removed from the water. The hydrophone was then moved to position B, the panel placed in the water, and the reflected sound level recorded.

The acoustic tests on panel #113A were measured at a water temperature of 8.0°C. The acoustic tests on panel #114 were measured at water temperature of 13.4°C. The water temperatures for the acoustic tests of panels #177 and #193R were 13°C and 10°C, respectively. Other conditions during measurements on all four of the panels were:

Depth:	14 feet
Rotation:	Clockwise
Measurement Method:	Pulse Technique
Accuracy of Measurement:	Plus or Minus 1.0 db
Equipment:	Hazeltine's Acoustic Measurement System Projector - USN J-11 Hydrophone - USN M115B Serial 407
Mode:	Omni Directional
Frequency Range:	1 kHz through 20 kHz

Transmission Levels

Figures 8 through 11 present the transmission level versus frequency at normal incidence for panels #142, #143, #144, and #145, respectively. Measurements were taken with the damping material facing the projector. In the range from 3 kHz to 8 kHz: the transmission loss through panel #142 (1/4 inch of 80A plus 1/4 inch of 80-2K-WR) (Figure 8) varied from 4 db to 10 db more than that of a bare 30" x 30" x 1/4" HY-80 steel plate (Ref. #47); the transmission loss of plate #143 (1/2 inch of 80-2K-WR) (Figure 9) was 0 db compared to a bare steel plate. In other words, the 80-2K-WR damping material had negligible transmission loss; the transmission loss through plate #144 (1/2 inch thickness of 80A) (Figure 10) was 0 db to 1 db more than that of a bare HY-80 steel plate; and the transmission loss of plate #145 (1/2 inch thickness of 80A with a sealant) (Figure 11) varied from 0 db to 1 db more than that of a bare HY-80 steel plate.

Figures 12 and 13 present the transmission level versus frequency at normal incidence for panels #113A and #114, respectively. In the frequency range from 3 kHz to 8 kHz; the transmission loss through panel #113A (1/2 inch thickness of 80-2K-WRA) (Figure 12) varied from 2 db to 5 db more than that of a bare steel plate; and the transmission loss through panel #114 (1/2 inch thickness of urethane) (Figure 13) varied from 2 db to 4 db more than that of a bare HY-80 steel plate. It is of interest to state here that an oily substance oozed out of the urethane coating when this material was submerged in the water.

Transmission level measurements on an 18.5" radius curved by 48" high by 1/4 inch thick HY-80 steel plate (panel #177) with a 1/2 inch thickness of 80-2K-WR applied to the inside showed 1.0 db less at the SQS-26 Sonar frequency, 5 db more at the SQS-23 Sonar frequency, and 1.5 db more at the SQS-35 Sonar frequency than the transmission loss of a curved panel of the same size and shape, but uncoated. For an AN/SQS-26 Sonar dome section coated on the inside with a 1/2 inch thickness of 80-2K-WR (excluding trusses), the transmission loss was 2.0 db more at the SQS-26 Sonar frequency, 4.0 db more at the SQS-23 Sonar frequency, and 2.5 db more at the SQS-35 Sonar frequency, than that of an undamped AN/SQS-26 Sonar dome section.

Reflection Levels

Figures 14 and 15 present the reflection levels versus frequency at normal incidence for panels #113A and #114, respectively. In the frequency range from 3 kHz to 8 kHz: the reflection level from panel #113A (Figure 14) varied from 8.5 db less than, to 3.5 db more than, that of a bare HY-80 Steel plate; the reflection level from panel #114 (Figure 15) varied from 1.5 db less than, to 4 db more than, that of a bare HY-80 Steel plate.

The reflection level on a curved steel plate (panel #177) with a 1/2 inch thickness of 80-2K-WR applied to the inside showed 1.5 db less at the SQS-26 Sonar frequency, 4 db less at the SQS-23 Sonar frequency, and 0 db at the SQS-35 Sonar frequency than that of a bare HY-80 steel panel of the same size and shape. The reflection level of an AN/SQS-26 Sonar dome section (panel #193R) coated on the inside, excluding trusses, with a 1/2 inch thickness of 80-2K-WR was 2 db less at the SQS-26 Sonar frequency, 1.5 db less at the SQS-23 Sonar frequency, and 5 db less at the SQS-35 Sonar frequency, than that of an undamped AN/SQS-26 Sonar dome section.

HIGH POWER SONAR TRANSMISSIONS

Tests are made on products intended to be used in sonar domes to determine whether or not they can withstand, without deterioration, the effects of high power transmissions. The test setup that USL has developed for this purpose is described in reference (d).

Panel #143 (1/2 inch thickness of 80-2K-WR) was submerged in the Thames River salt water from 20 August to 20 September 1965, during which it was subjected to 175 hours of high power sonar transmissions. No sign of degradation of the material was observed; however, there was quite extensive hair-like marine growth on the material.

CONCLUSIONS

The 80-2K-WR damping material was found to exhibit good damping and acoustic characteristics when applied to a flat plate. However, when it was applied to an AN/SQS-26 Sonar dome section, the acoustic properties were degraded seriously, probably due to air entrapped when the material was applied to the complex structure. If this material were to be applied on a full-size dome, an efficient application technique would need to be developed.

Howard N. Phelps, Jr.
HOWARD N. PHELPS, JR.
Mechanical Engineer

LIST OF REFERENCES

(a) Data Sheet of Korfund Vibrodamper Compound Type 80A, Type 80-2K-WR, Korfund Dynamics Corporation, Westbury, Long Island, New York, March 1, 1964.

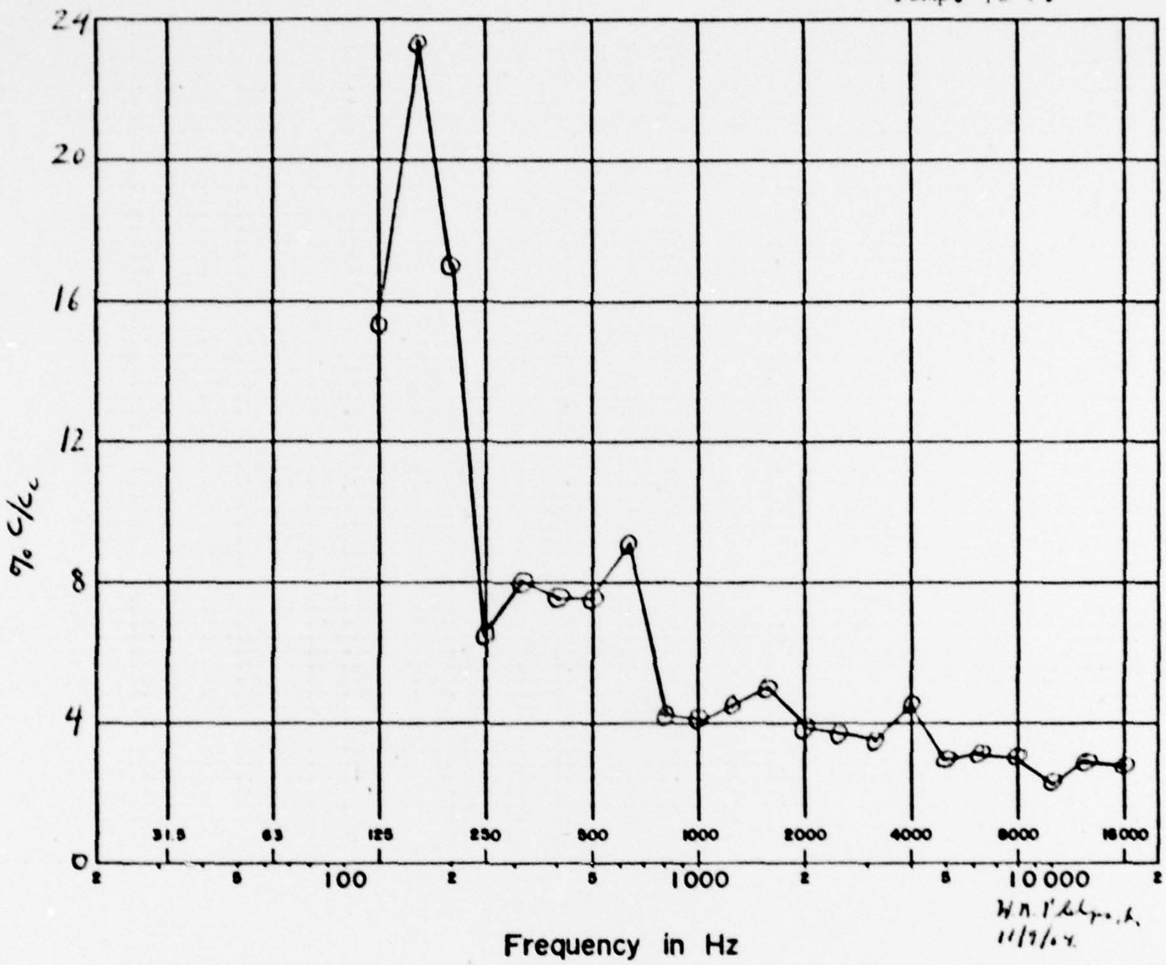
(b) H. N. Phelps, Jr., "Damping Characteristics of Three Untreated Steel Plates," USL Technical Memorandum No. 933-54-64, 17 February 1964.

(c) H. N. Phelps, Jr. and M. F. Borg, "Calibration of Instrumentation for Vibration and Damping Tests," USL Technical Memorandum No. 933-236-63, 22 August 1963.

(d) J. O. Natwick, "Test Method for Evaluating Sonar Dome Coatings," USL Technical Memorandum No. 933-0153-64, 19 June 1964 (CONFIDENTIAL).

DAMPING CHARACTERISTICS OF USL PANEL #142.

Temp. 70°F.



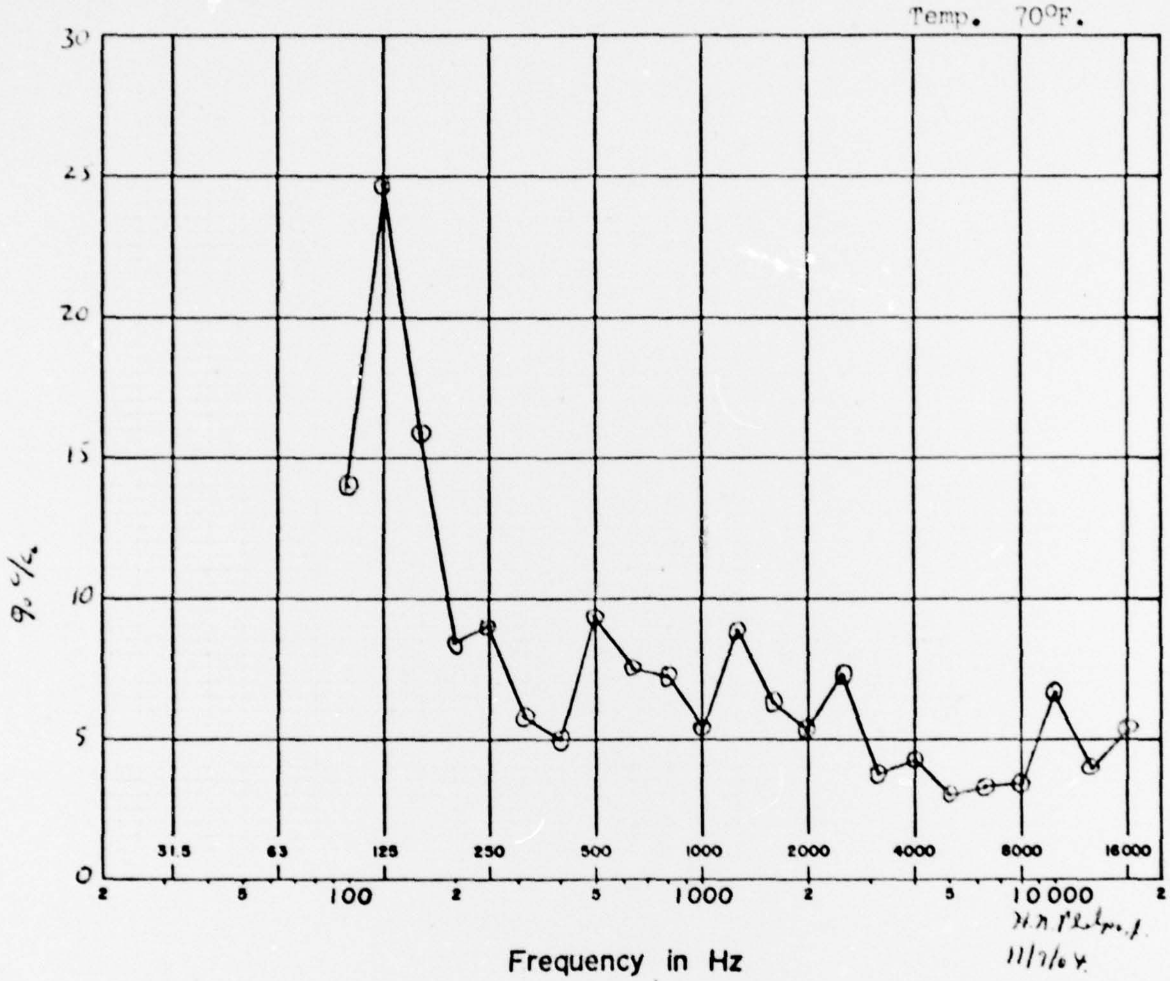
30" x 30" x ¼" HY-80 steel plate with a ¼-inch thickness of 80A and a ¼-inch thickness of 80-2K-WR damping compounds applied to one side.

Form 102

Figure 1.

USL TECH MEMO
No. 2133-257-69

damping
DAMPING CHARACTERISTICS OF PANEL #143.

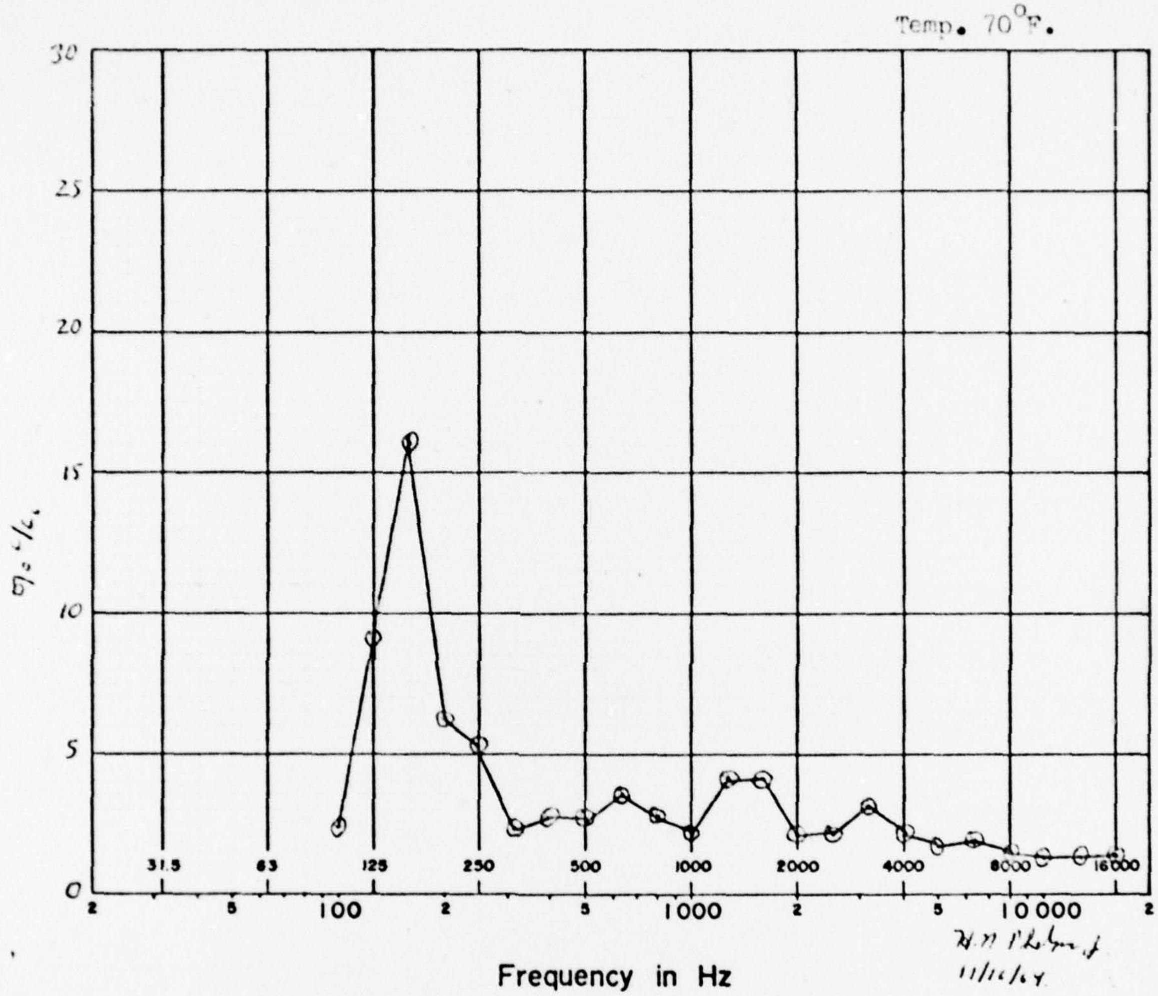


30" x 30" x $\frac{1}{4}$" HY-80 steel plate
with a $\frac{1}{2}$-inch thickness of 80-2K-WR
damping compound applied to one side.

Form 102

Figure 2.

DAMPING CHARACTERISTICS OF PANEL #144.



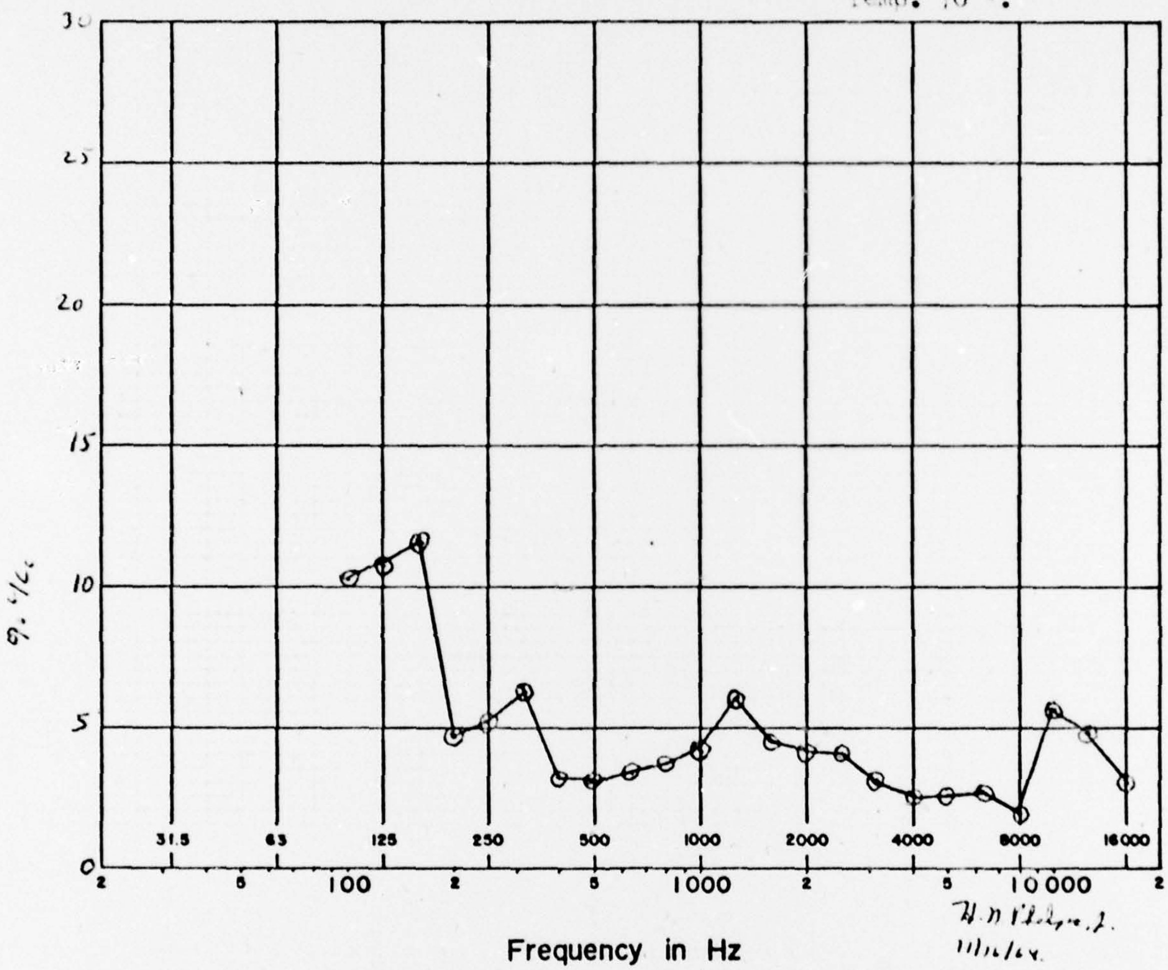
30" x 30" x ¼" HY-80 steel plate with a ½-inch thickness of 80A damping compound applied to one side.

Form 102

Figure 3.

Damping Characteristics of Panel #245.

Temp. 70°F.



30" x 30" x ¼" HY-80 steel plate with a ½-inch thickness of 80A damping compound applied to one side with a sealant applied over the damping compound.

Form 102

Figure 4.

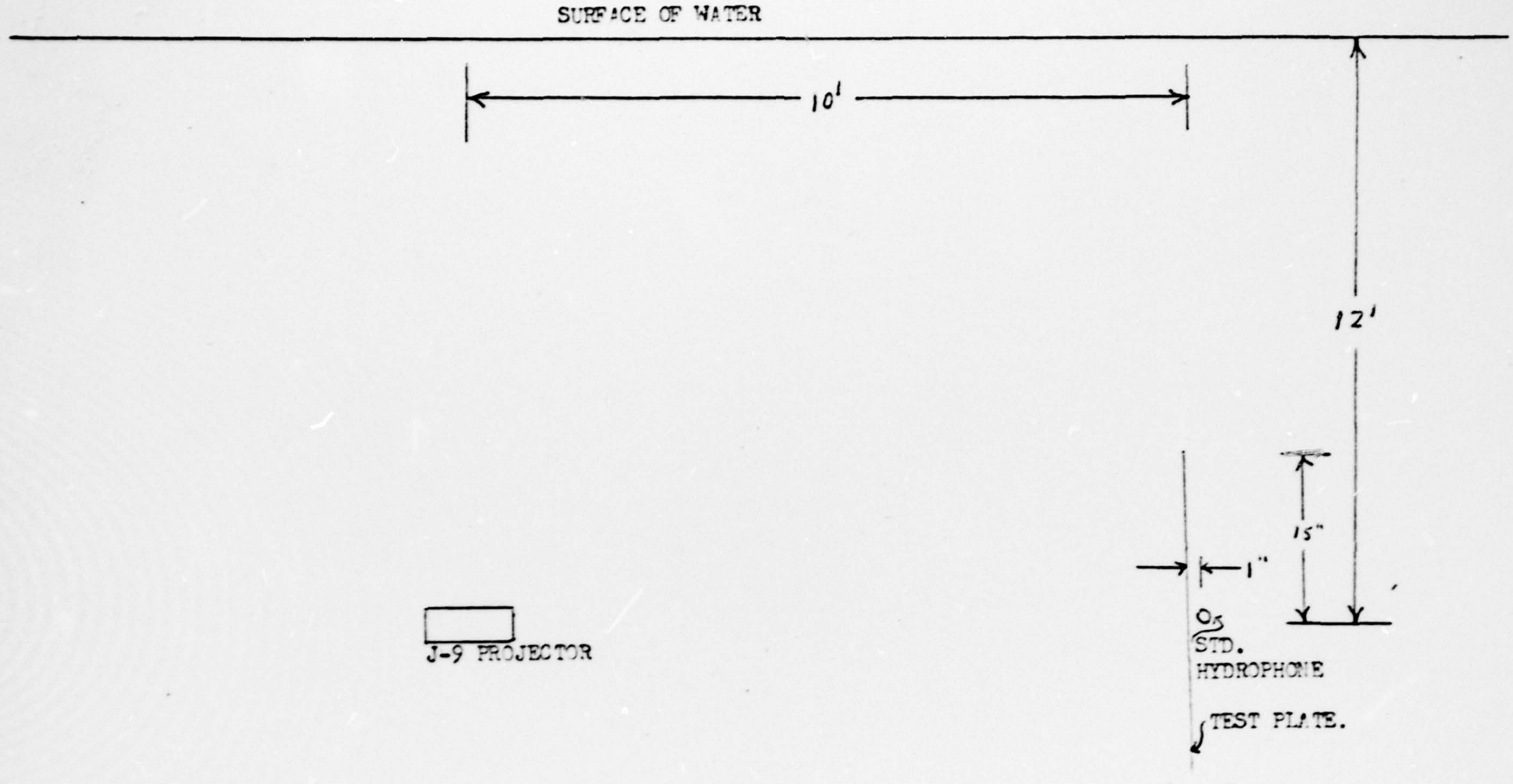

SURFACE OF WATER
10'
12'
15"
1"
STD.
HYDROPHONE
TEST PLATE.
J-9 PROJECTOR

Figure 5.

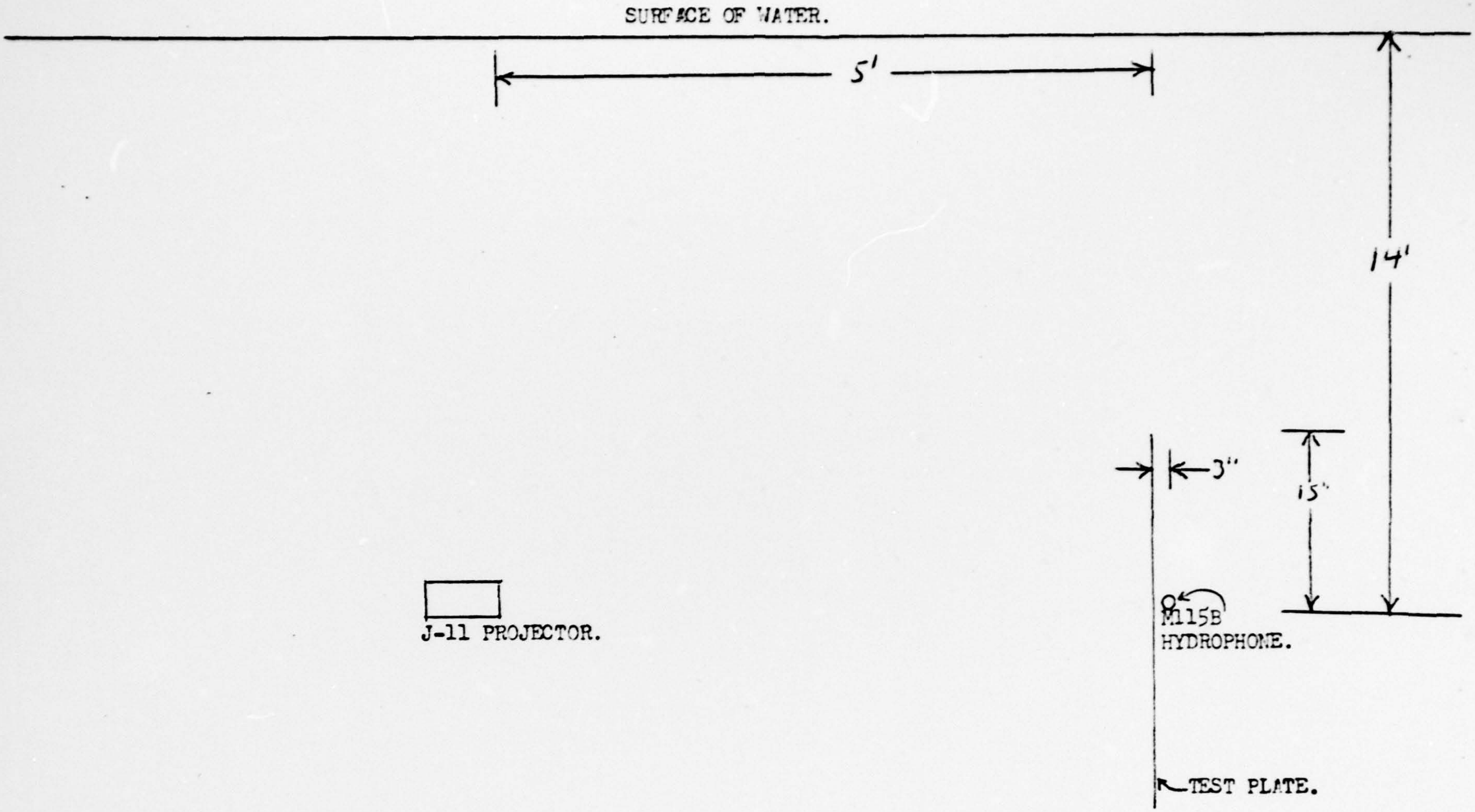

SURFACE OF WATER.
5'
14'
15"
3"
M115B
HYDROPHONE.
J-11 PROJECTOR.
TEST PLATE.

Figure 6.

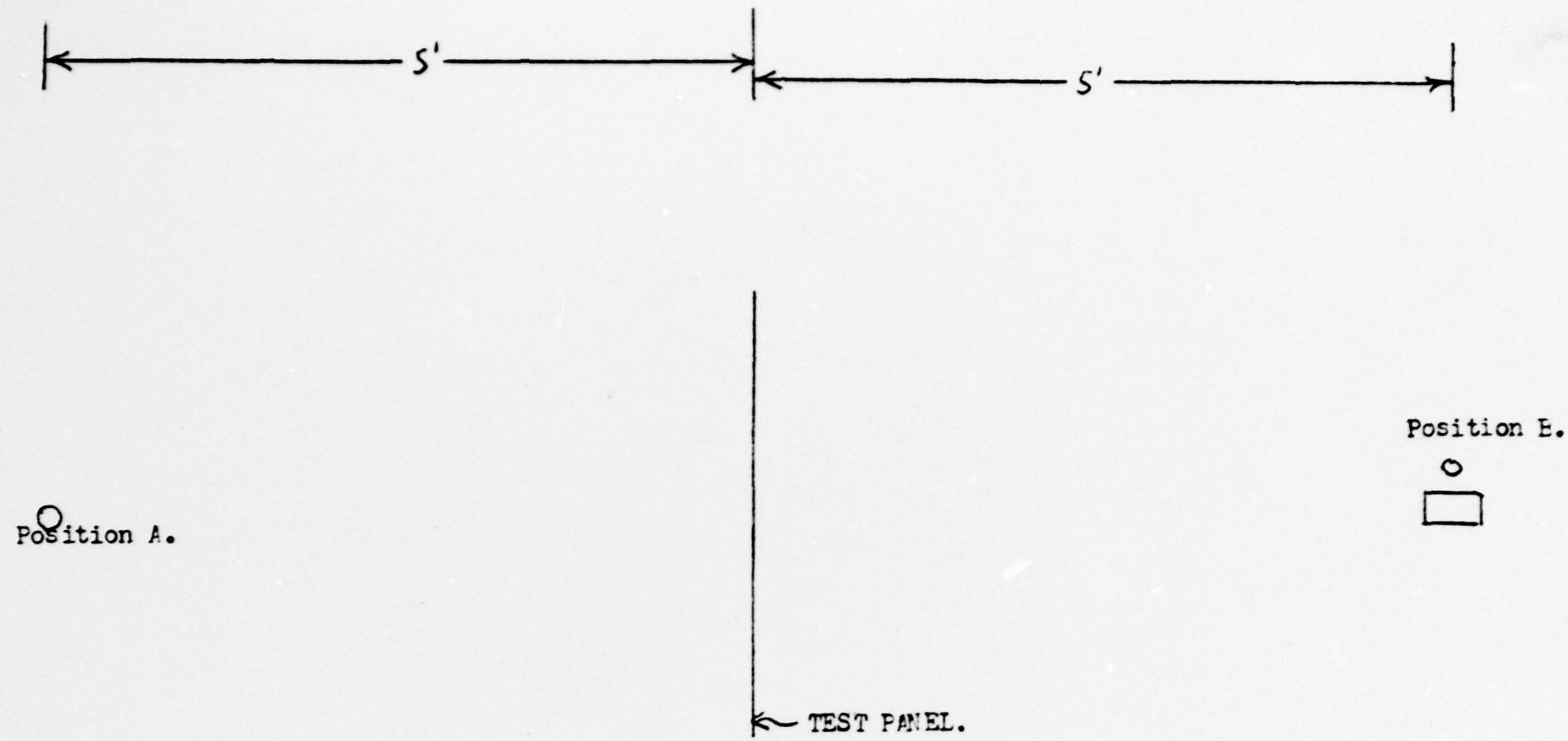


Figure 7.

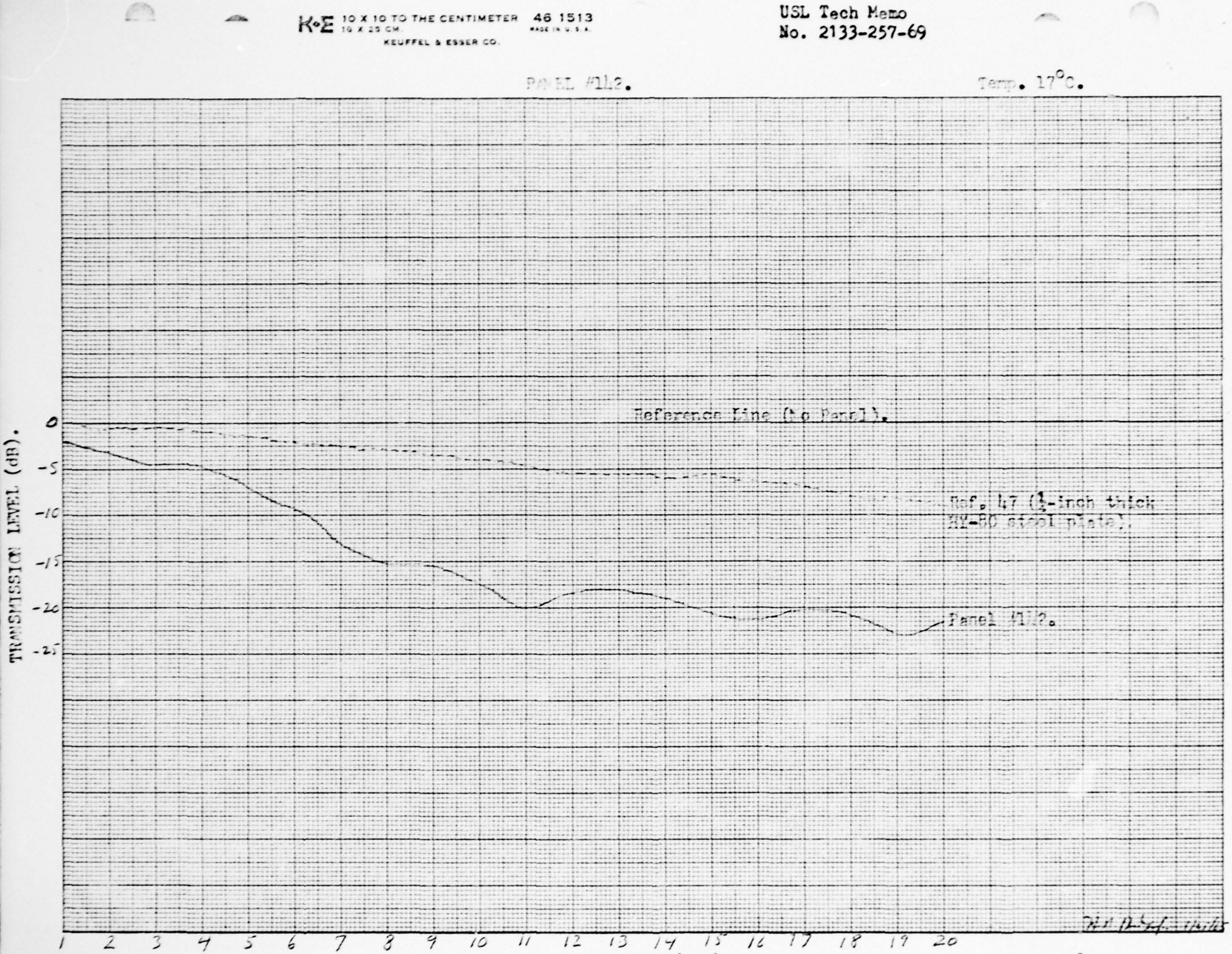

K-E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.
PANEL #112.
Temp. 17°C.
Reference Line (No Panel).
Ref. 47 (½-inch thick HY-80 steel plate).
Panel #112.
TRANSMISSION LEVEL (dB).
0
-5
-10
-15
-20
-25
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
FREQUENCY (kHz)

Figure 8.

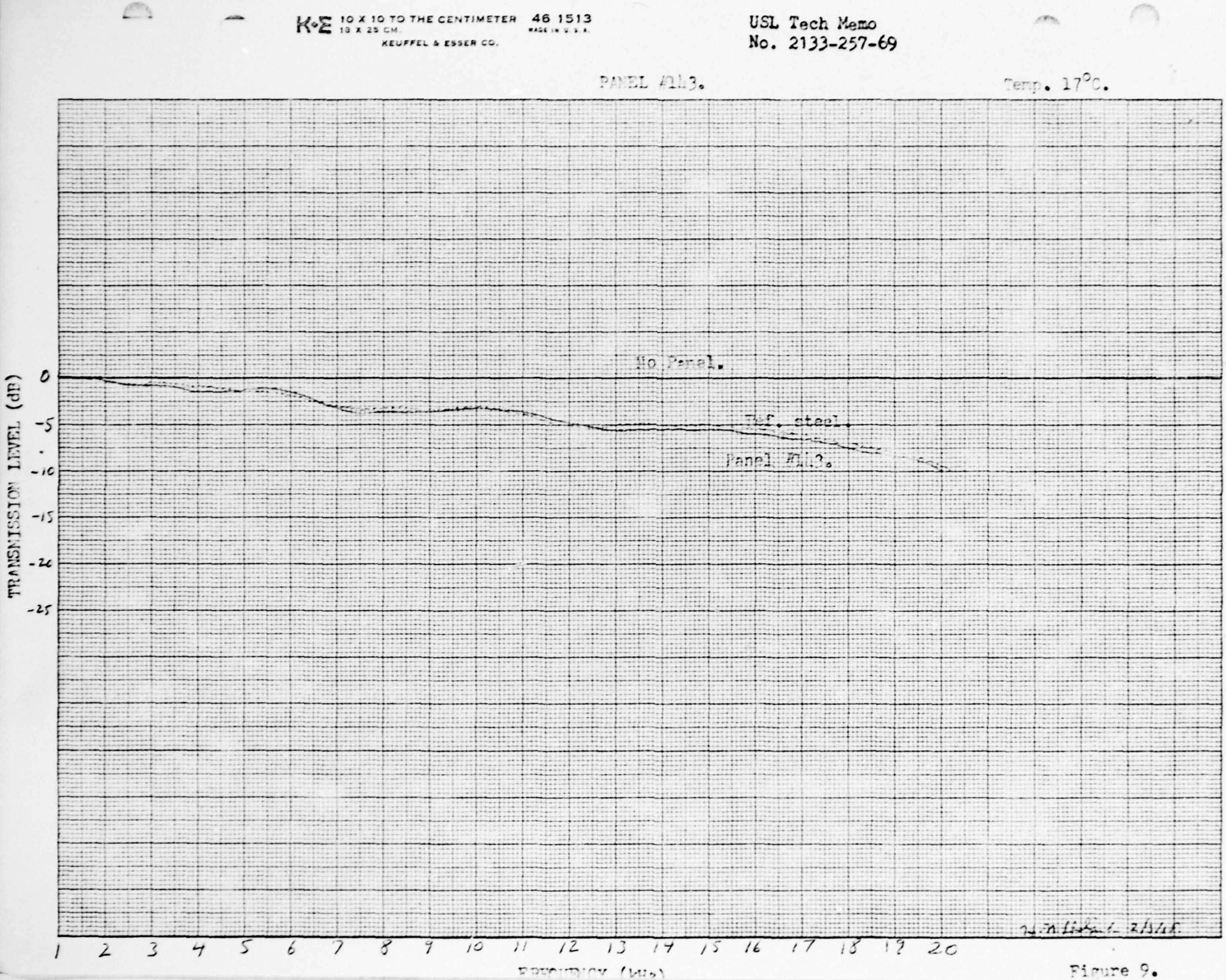

K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.
PANEL #143.
Temp. 17°C.
No Panel.
Ref. steel.
Panel #143.
0
-5
-10
-15
-20
-25
TRANSMISSION LEVEL (dB)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure 9.

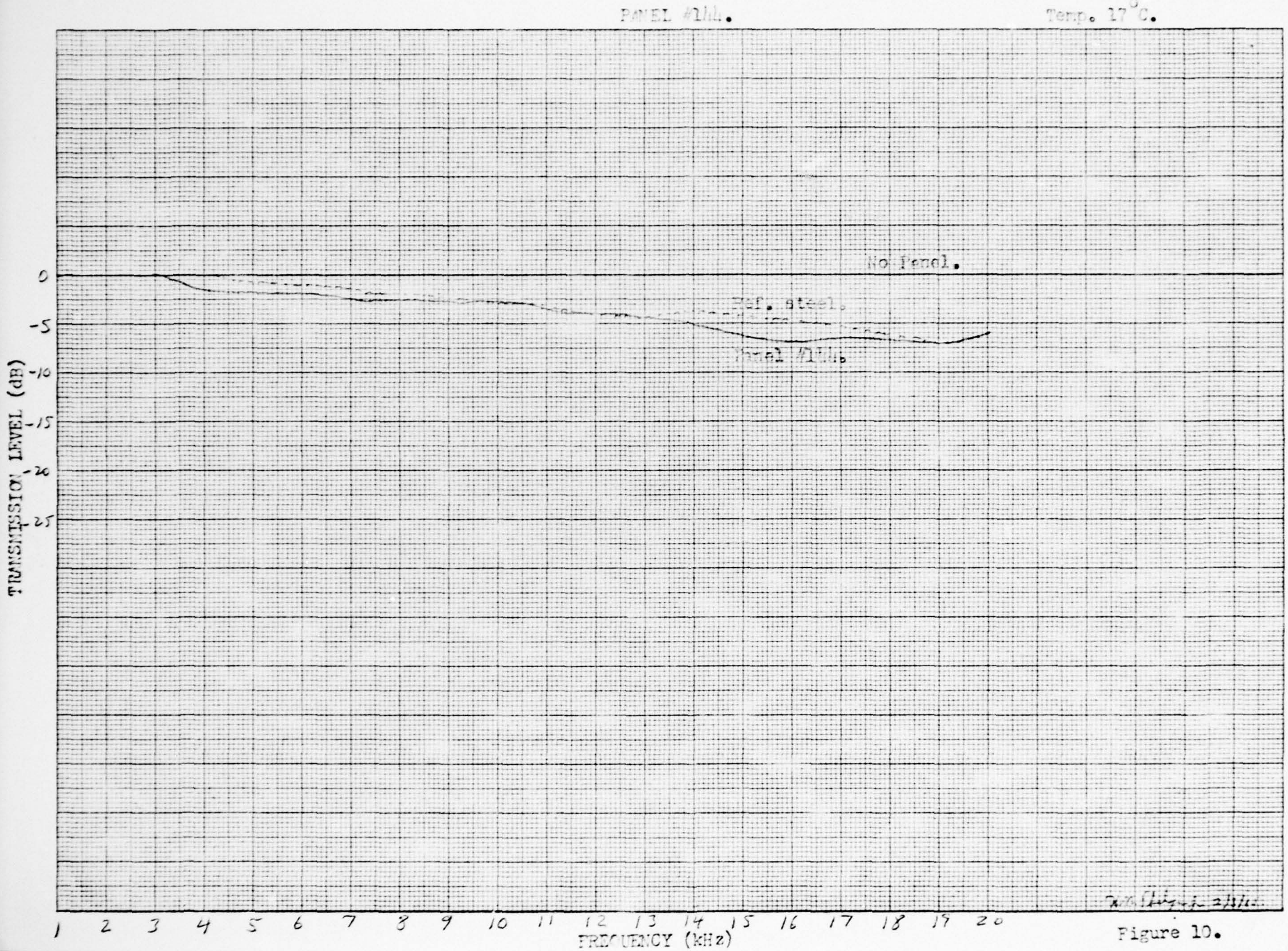

PANEL #144.
Temp. 17°C.
No Panel.
Ref. steel.
Panel #144.
0
-5
-10
-15
-20
-25
TRANSMISSION LEVEL (dB)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
FREQUENCY (kHz)

Figure 10.

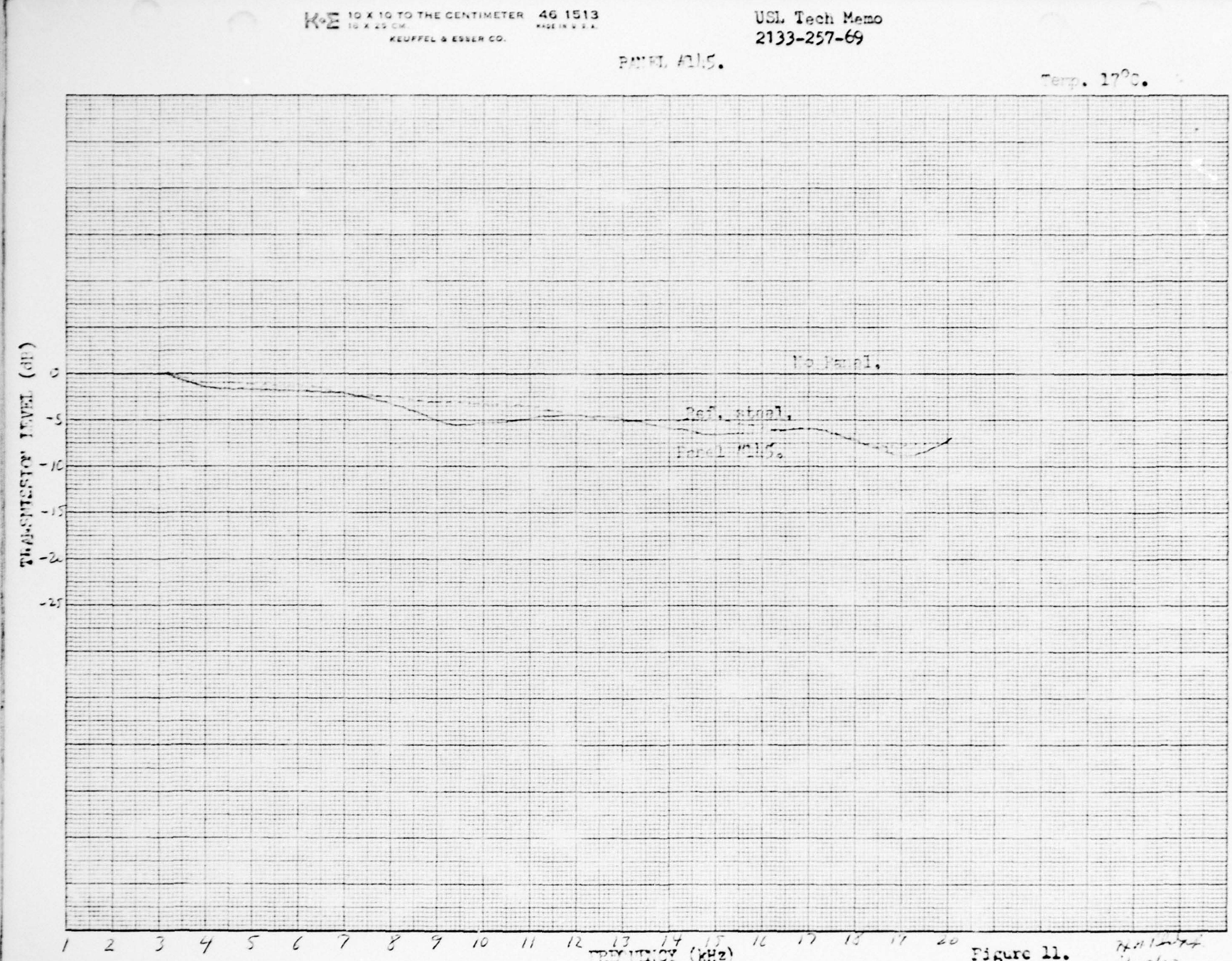

K+E 10 X 10 TO THE CENTIMETER 46 1513
10 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.
PANEL #215.
Temp. 17°C.
No Panel.
Ref. steel.
Panel #215.
TRANSMISSION LEVEL (dB)
0
-5
-10
-15
-20
-25
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
FREQUENCY (kHz)

Figure 11.

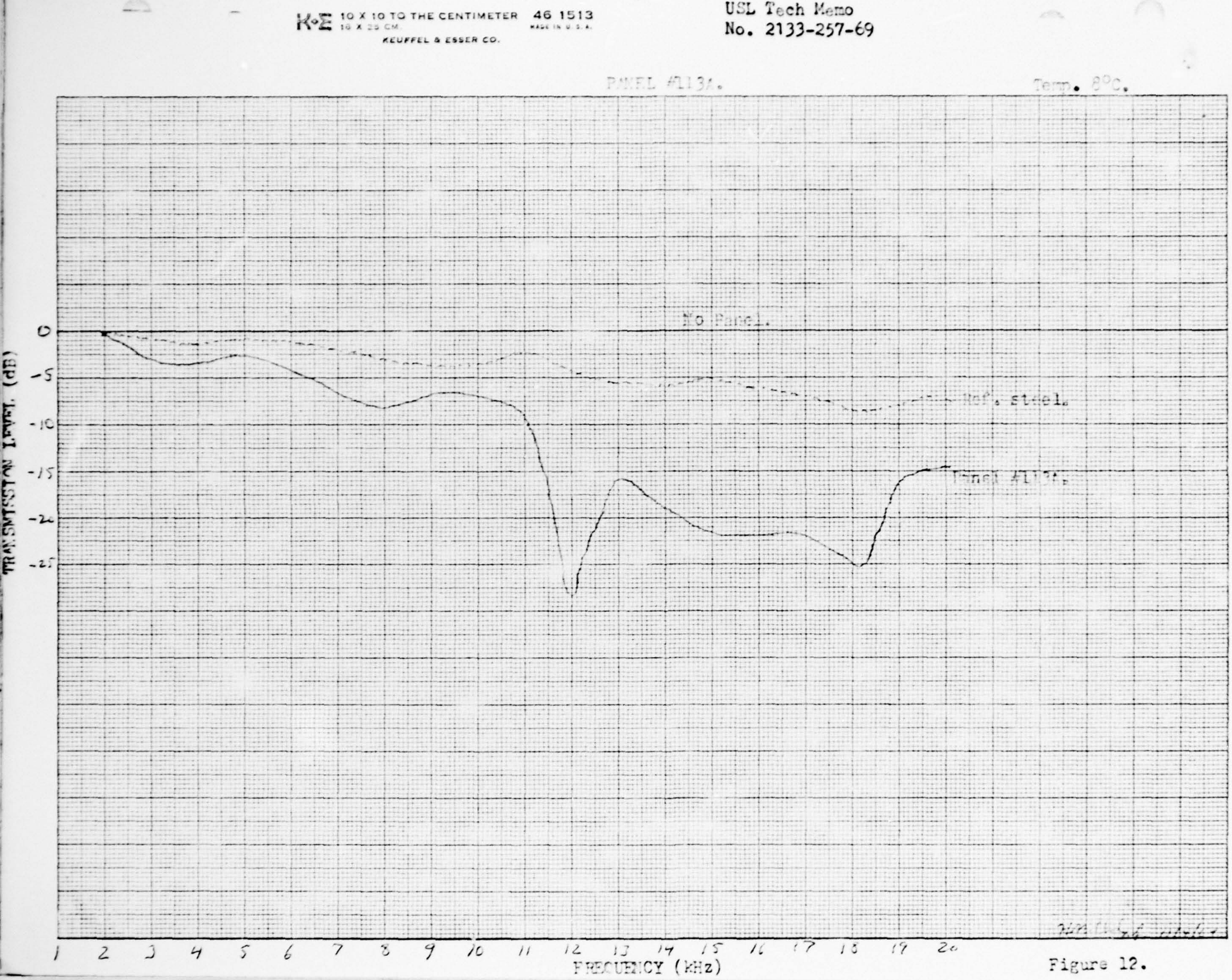

K+E 10 X 10 TO THE CENTIMETER 46 1513
KEUFFEL & ESSER CO.
PANEL #113A.
Temp. 8°C.
No Panel.
Ref. steel.
Panel #113A.
0
-5
-10
-15
-20
-25
TRANSMISSION LEVEL (dB)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
FREQUENCY (kHz)

Figure 12.

PANEL #114. Temp. 13.4°C.

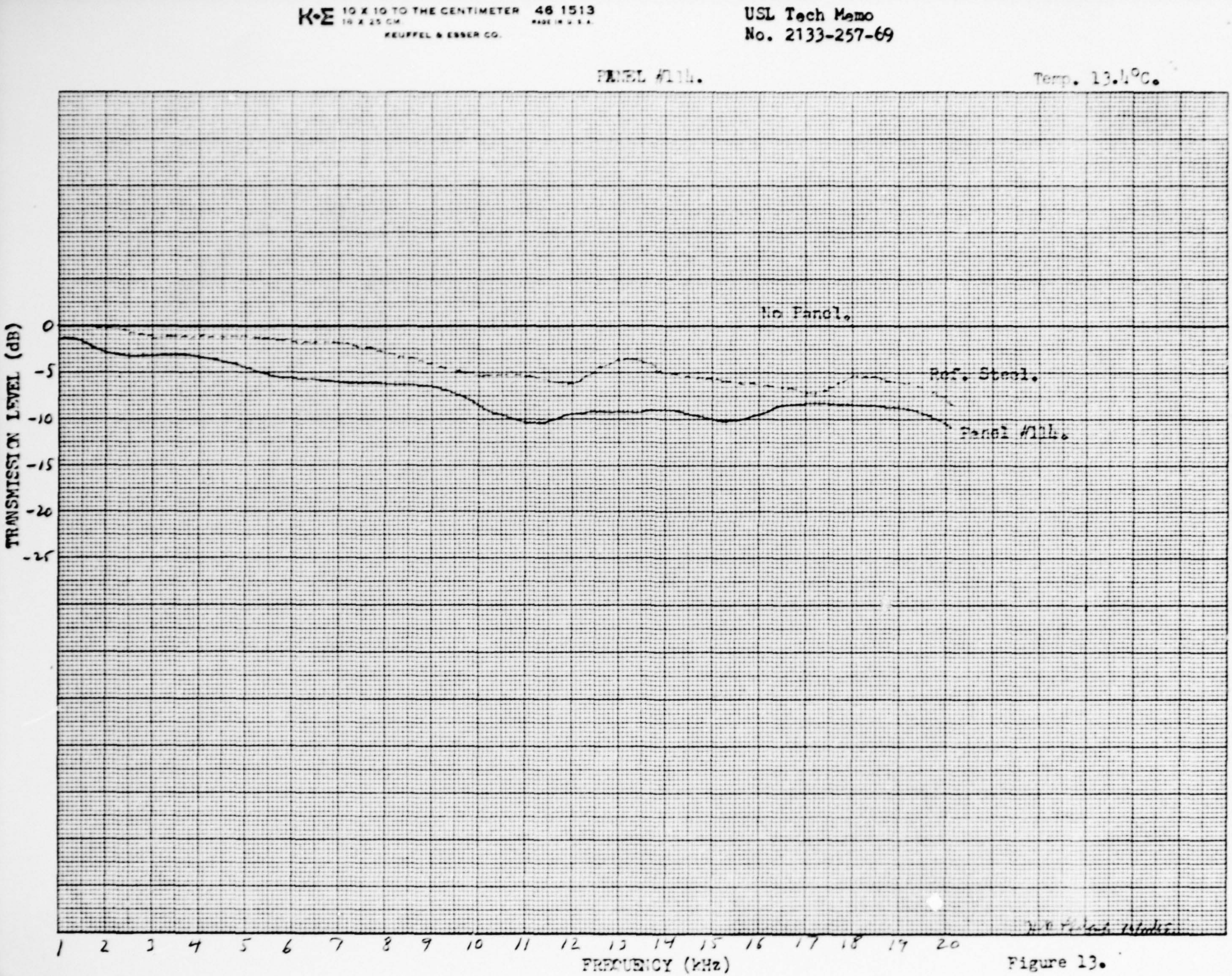


Figure 13.

PANEL #113A.

Temp. 8°C.

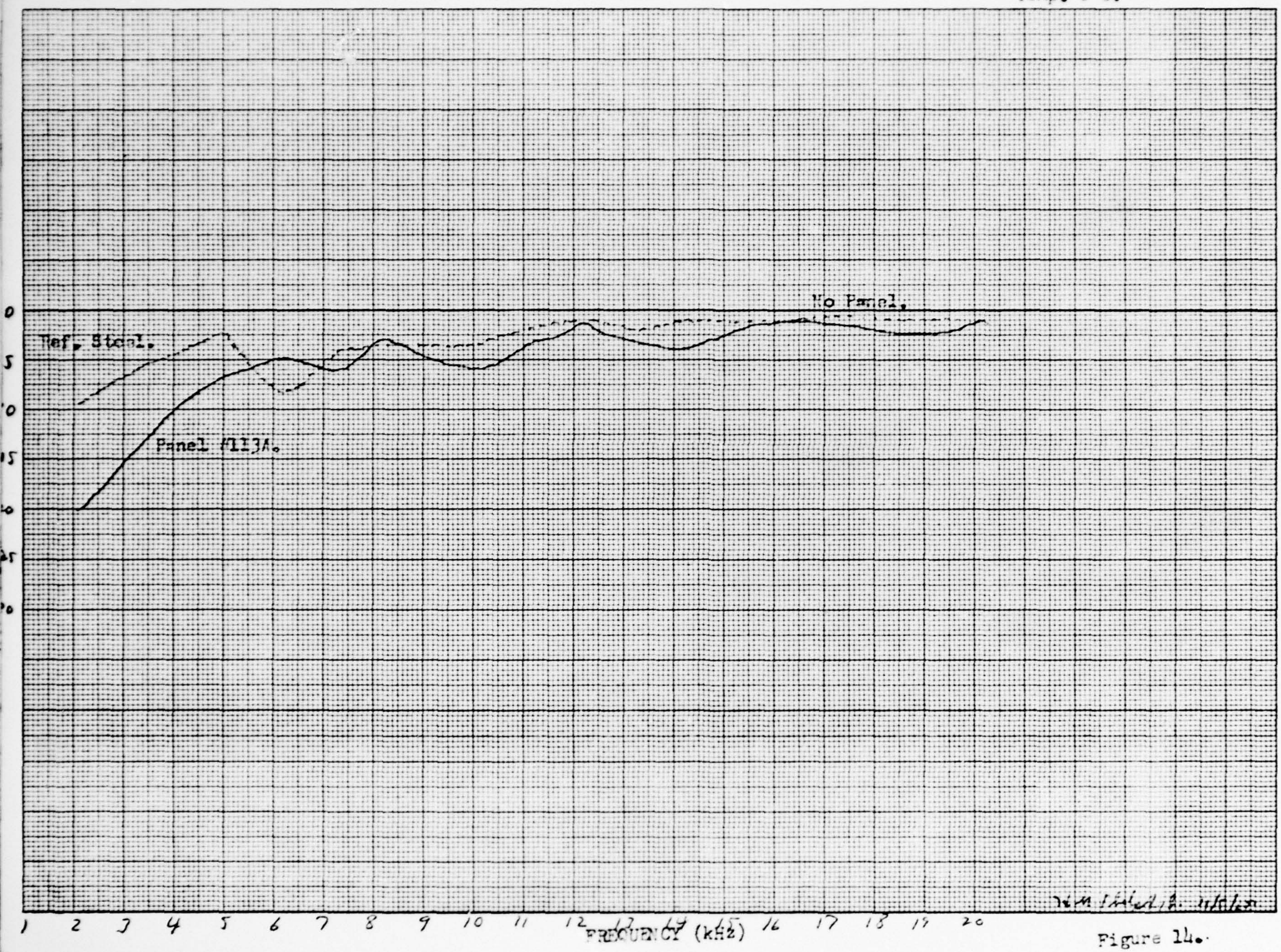


Figure 14.

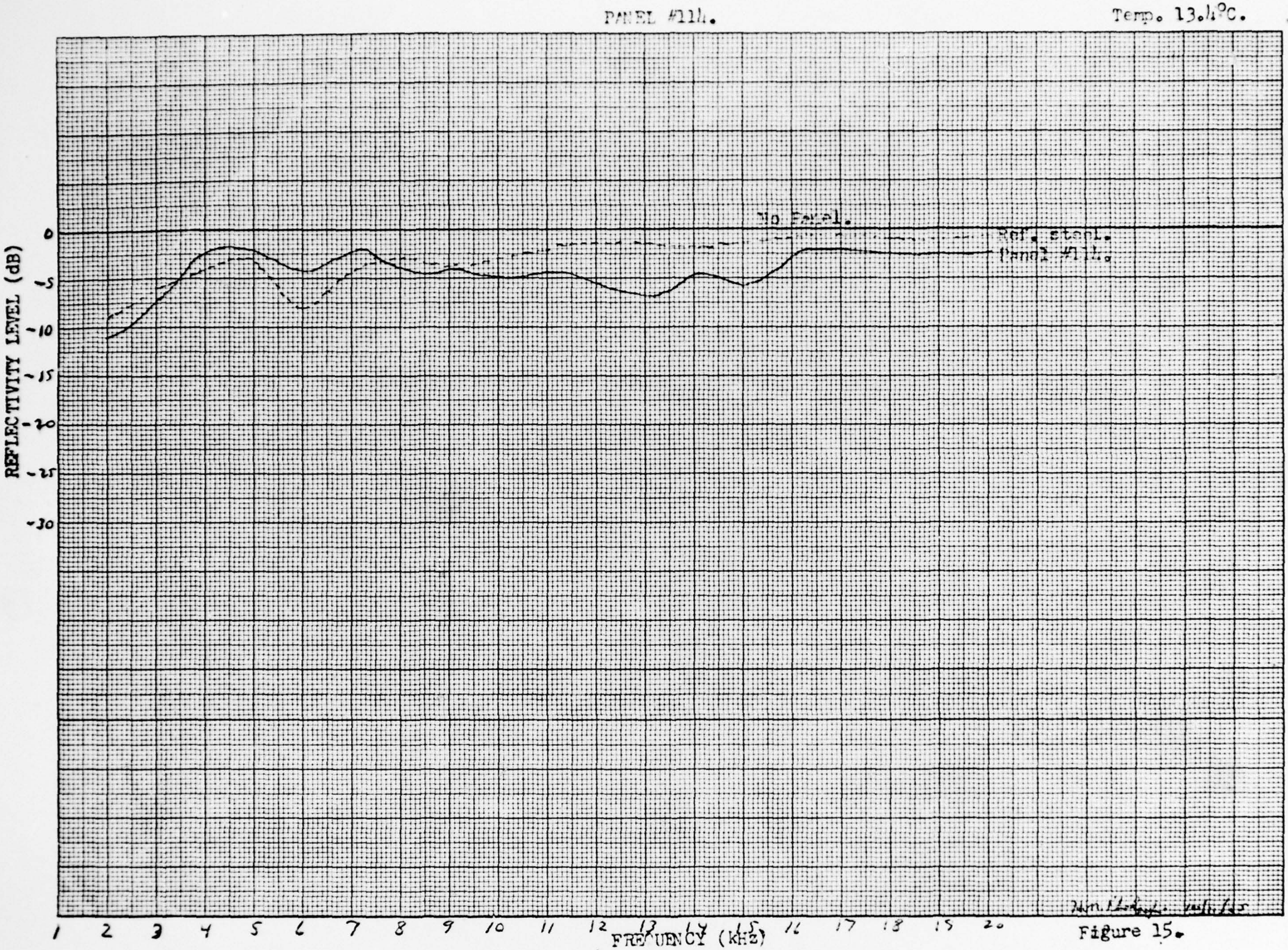

PANEL #114.
Temp. 13.4°C.
REFLECTIVITY LEVEL (dB)
0
-5
-10
-15
-20
-25
-30
No Panel.
Ref. steel.
Panel #114.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
FREQUENCY (kHz)

Figure 15.