Some tests on silencing the jet engine exhaust noise in No. 5 test cell
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SECURITY CLASSIFICATION OPEN

SUBJECT SOME TESTS ON SILENCING THE JET ENGINE EXHAUST NOISE IN NO. 5 TEST CELL.

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ISSUED TO INTERNAL

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SUMMARY

The temperature and velocity distribution in the last element of the multiple ejector exhaust duct was measured, using television for instrument readings. These measurements were made with uncovered and covered annular slots of the multiple ejector. No difference in outside noise level was found in these two cases.

Two screens have been tested successively. The first one ("engine screen") was mounted vertically on the exhaust duct inlet. The second one ("stack screen") was mounted horizontally on the exhaust elbow in the stack. The reduction of the outside noise level by the engine screen alone, was 12 - 14 decibels, depending on measuring distance. The reduction due to the stack screen alone was 4 - 5 decibels. However, both screens together reduced the noise by 13 - 15 decibels. It can be deduced from these results that the stack screen suppresses the engine noise coming through the exhaust duct and it does it appreciably only in case when this noise is not reduced at the engine itself.

SOME TESTS ON SILENCING THE JET ENGINE EXHAUST NOISE IN NO. 5 TEST CELL

1.0 INTRODUCTION

The present tests were made as a part of the programme to reduce the jet engine noise in the neighbourhood of the Engine Laboratory. One of the objectives was to determine the disputed, unknown effect of the stack screen.

2.0 INSTALLATION

The engine used for the tests was an Orenda Mk. 14. The previously installed multiple ejector exhaust duct comprises six elements of the following dimensions (starting from the engine): 30 in. o.d. x 6 ft.; 38 in. o.d. x 6 ft.; 42 in. o.d. x 8 ft.; 48 in. o.d. x 4 ft.; 54 in. o.d. x 10 ft.; 60 in. o.d. x 15 ft. All elements have the wall thickness of 1/4 in. They overlap each other by approximately 1 foot. The last element immerges into exhaust elbow of 72 in. o.d.

For measuring the velocity distribution a "rake" of nine pitot tubes (Inconel tubing 1/4 in. o.d.) was used, mounted in the outlet of the 60 in. o.d. duct element. The pitots were connected to the airspeed indicators (Collens Instrument Company, New York, max. speed 300 m.p.h.) mounted on the special panel in the test cell, close to the exhaust duct in order to spare the length of connections. The readings were made by means of television, as shown in Figures 1 and 2.

Based on previous experience, the temperature distribution was expected to be very flat; the temperatures were measured therefore at three points only, close to the walls and on the axis of the duct element. A chromel-alumel wire was used for thermocouples.

A 1/4 inch diameter mild steel wire was used for the screen mounted vertically on the inlet of the exhaust duct close to the engine final nozzle ("engine screen", see Fig. 3). A 3/8 inch diameter concrete reinforcing rod was employed for the screen mounted horizontally on the exhaust elbow ("stack screen", see Fig. 4). Both screens had approximately 1 inch mesh.

The noise level measurements were made using a sound level meter type 1408-B (Dawe Instruments Limited) at three stations:

Station 1: Between Low Temperature Laboratory and water tower.
Station 2: At searchlight close to the water tower.
Station 3: At Hydro fence corner close to the old garage.

According to the manufacturer's operating instructions, if the sound is coming mainly from one direction the instrument should be held in front of the observer so that he does not form an acoustic reflector and the sound passes across the face of the microphone from one side. The microphone should not be pointed towards the source of sound. Since the previous measurements were made often in the latter position, the present readings were made in both positions of the instrument for comparison. The readings in the incorrect position are given in brackets.

For tests with screens, an Ampex model 600 Tape Recorder was additionally used. The location of the microphone was on the Engine Laboratory roof, approximately 15 feet from the exhaust stack wall.

3.0 TEST RESULTS AND DISCUSSION

3.1 Tests with Multiple Ejector

Figure 4 shows the velocity and temperature distribution in the last element of the multiple exhaust ejector just at the entrance to the exhaust elbow. In one case all annular slots were open, in second case four slots were temporarily covered (leaving the first and the last one uncovered). This of course reduced the amount of induced air and raised the temperature of the gases. The comparison could be made for the engine with no reheat only, because for the reheated engine and uncovered slots the velocity of the gases exceeded the capacity of the instruments used. The maximum gas velocity with uncovered slots was 280 m.p.h., and the temperature 100°C. With covered slots the gas velocity was 200 m.p.h., and the temperature 120°C. In spite of marked differences in velocities, no difference in outside noise level could be noticed in both cases.

3.2 Tests with Screens

A screen was installed horizontally above the exhaust elbow ("stack screen"). It was mounted first at a 10 inch distance from the outlet of the elbow, but the preliminary tests showed that the "0" distance was slightly better. An "engine screen" was mounted on the inlet of the exhaust duct at a 14 inch distance from the final engine nozzle. However, it was buckled in previous experiments by approximately 3 inches. The results obtained with these screens separately and combined, are given below. All tests were made on the same day.

Date: 25 Feb. 1957. Bar. Pressure: 753 mm. t_{amb}: -4°C

Engine Speed: 7600 r.p.m. observed.

			Station 1	Station 2	Station 3
A)	No Screen	db.	111-112 (113)*	109-110 (113)	100-101 (103-104)
B)	Stack Screen Only	db.	107-108 (110)	104-105 (118)	96 (99)
	Difference between A and B	db.	4	5	4-5
C)	Engine Screen Only	db.	98 (99)	96-97 (99)	88-89 (91-92)
	Difference between A and C	db.	13-14	13	12
D)	Both Screens	db.	96-97 (98)	95 (97-98)	87 (91-92)
	Difference between A and D	db.	15	14-15	13-14

* N.B. The figures in brackets refer to the incorrect position of the sound level meter.

It can be seen from these results that the stack screen alone reduced the outside noise by 4 - 5 db., depending on measuring distance. The engine screen suppressed the noise by 12 - 14 db. However, the reduction in noise level obtained with both screens was 13 - 15 db. Apparently the stack screen reduced the engine noise coming through the exhaust duct appreciably only in case when it was not yet suppressed at the engine itself.

The noise tests with the screens were also recorded by an Ampex tape recorder, using a microphone located on the Engine Laboratory roof. Thor Weibust operated the instrument and evaluated the results. From the attached diagrams it can be seen (Fig. 6) that they agree very well with measurements by the sound level meter.

No adverse effect by any or both screens was noticed on the engine characteristics, such as, temperatures, thrust, etc.

4.0 CONCLUSIONS

The engine screen reduced quite appreciably the outside noise level and further work may be worthwhile, perhaps using more than one screen, to determine the conditions which will give the best effect.

FIG. 1 TELEVISION USED FOR REMOTE INSTRUMENT READING

FIG.2 TELEVISION USED FOR REMOTE INSTRUMENT READING

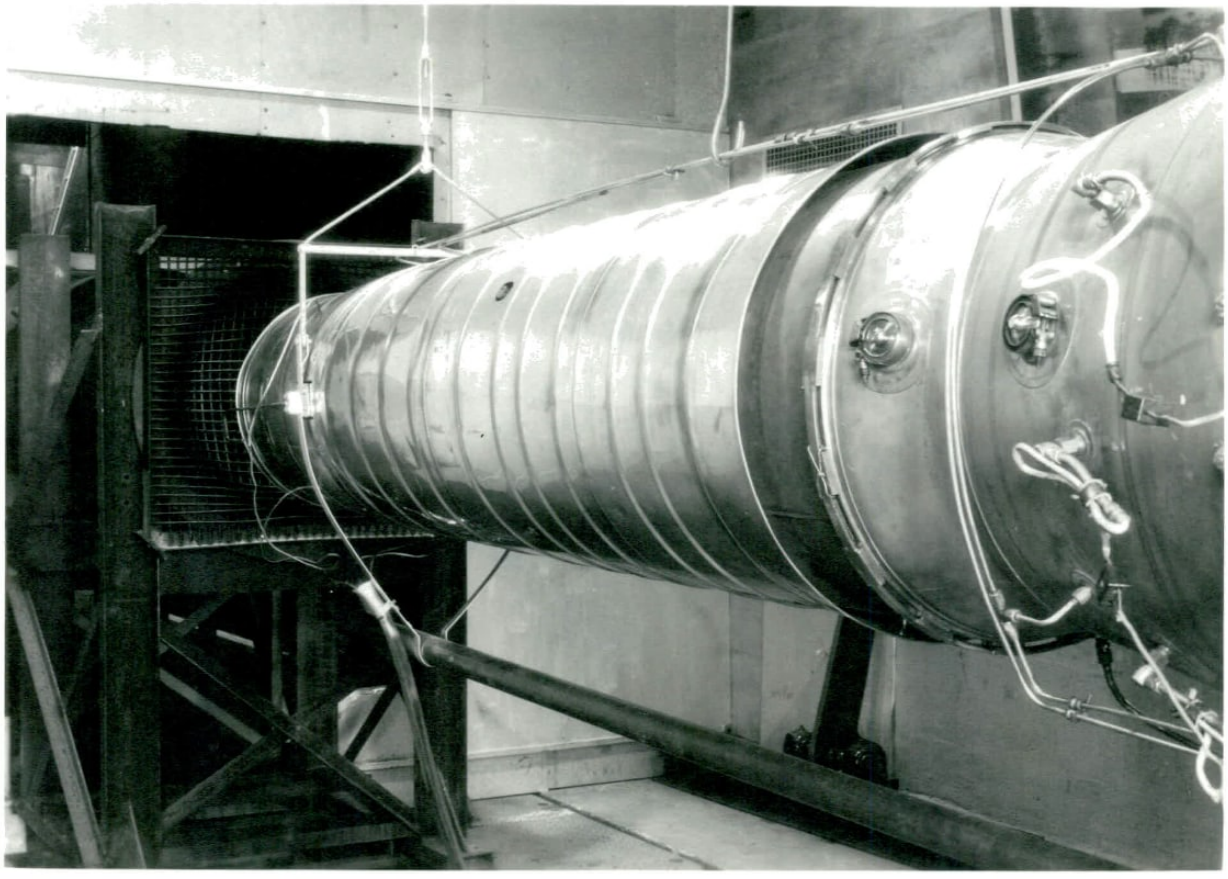


FIG 3 ENGINE SCREEN

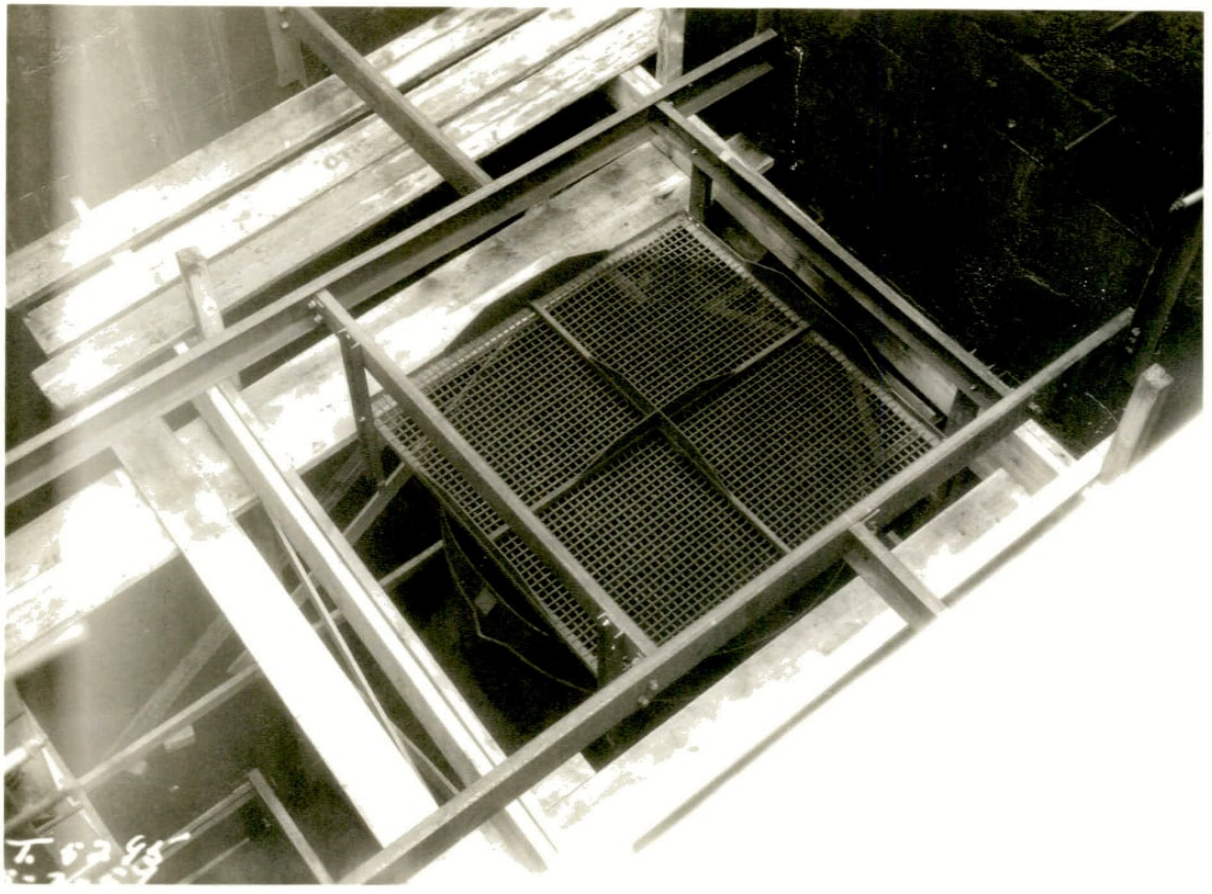


FIG.4 STACK SCREEN

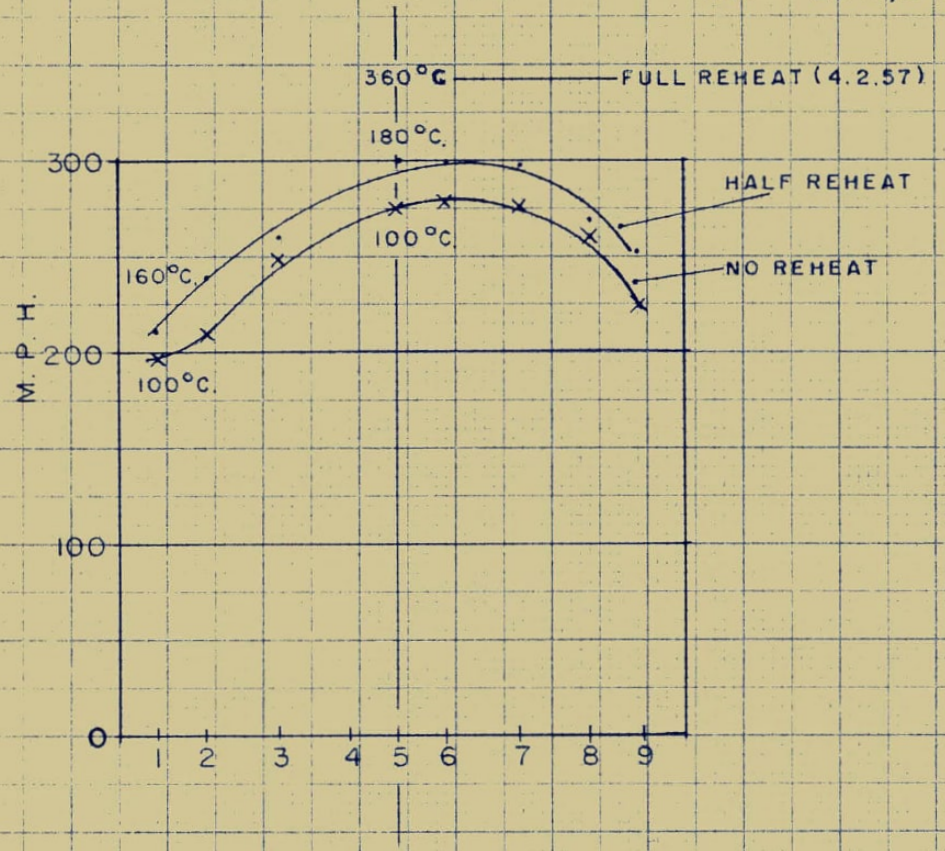
MULTIPLE EJECTOR TESTS

TEST CELL No. 5

JAN. 14-57

CORR. ENGINE SPEED: 7600 R.P.M.

t_{amb} = -25°C, b = 759 mm Hg



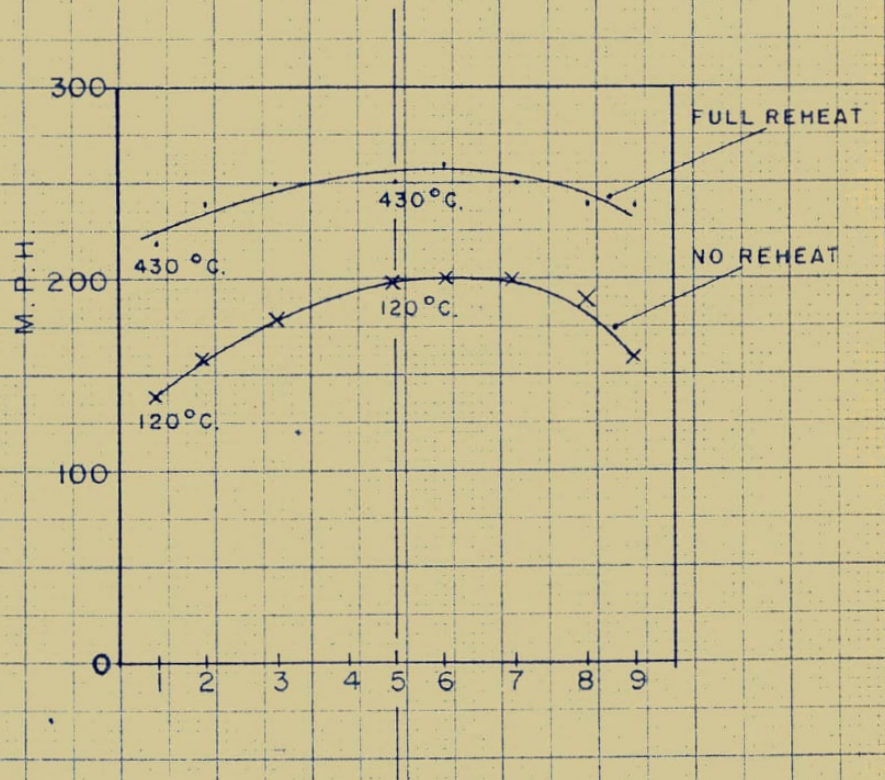


FIG. 5

359-71 KEUFFEL & ESSER CO.
Semi-Logarithmic, 3 Cycles × 10 to the inch,
5th lines accented.
MADE IN U. S. A.

1/3 OCTAVE BAND NOISE SPECTRA OF ORENDA 14 IN No.5 TEST CELL USING SCREENS AS NOISE SUPPRESSORS

RECORDED FEB.25-57
RECORDER T.W.

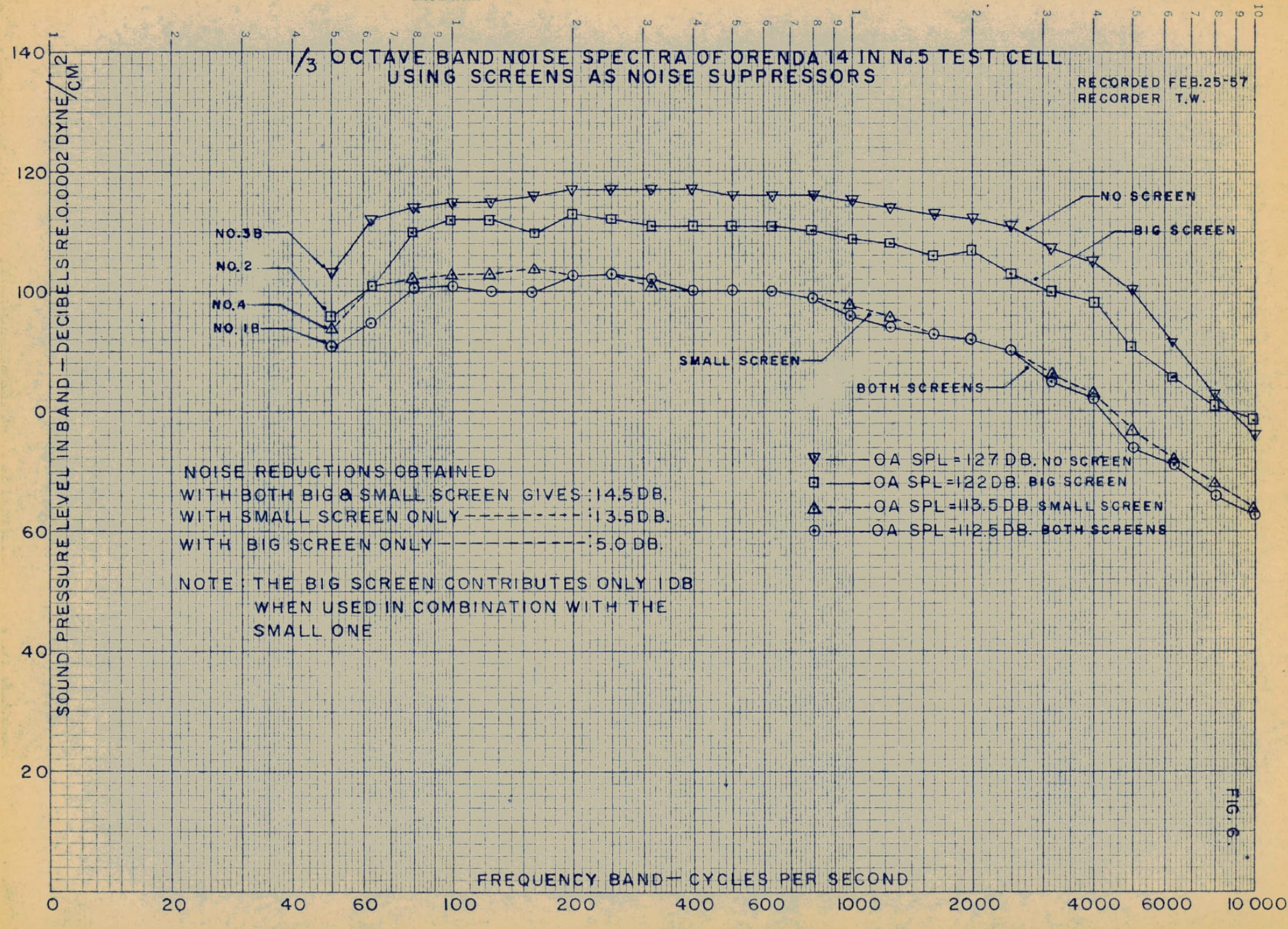


FIG. 6.