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by

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A BATTERY-OPERATED FOUR-CHANNEL TAPE RECORDER FOR USE IN ACOUSTIC MEASUREMENTS IN FLIGHT

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SUMMARY

This report describes a self-contained battery-operated four-channel tape recorder which has been designed particularly for the direct recording of audio frequency signals in a research aircraft where installation space was strictly limited and where no operating power was available from the aircraft electrical system.

*Replaces R.A.E. Technical Report 66319 - A.R.C. 28940

CONTENTS

1 INTRODUCTION

As part of a research programme to investigate certain acoustic loading actions in support of the Concord development, it became necessary to examine the pressure spectrum and likely structural response beneath the vortex that exists on the upper surface of highly swept wings.

For this purpose an experiment was planned using the HP 115 aircraft and this required the use of a multi-channel tape recorder having a frequency range from 50 c/s (Hz) to about 10 kc/s (kHz). Because of electrical power limitations on the aircraft the recorder had to be battery-operated, and since a recorder of this type was not commercially available it became necessary to make one at R.A.E. This report describes the four-channel recorder that has been made and its performance in a vibration environment.

2 DESIGN CONSIDERATIONS AND GENERAL DESCRIPTION

At the time design work was started on the recorder, the aircraft electrical system was being used to its maximum capacity for aircraft services and some other experimental apparatus. Because of this and because space available for installation was limited, the recorder was designed to be as small as possible and with an integral battery power supply. A frequency range of 50 c/s (Hz) to about 10 kc/s (kHz) and a recording time of at least 20 minutes were required.

Essentially the recorder consists of a tape transport mechanism, a power supply and control system, and recording amplifiers with associated input signal attenuators. Replay of records is done on a commercial machine which has been fitted with a suitable replay head. The tape must be erased in bulk before it is used for recording.

The recorder is 15 inches (38 cm) in length, 7.5 inches (19 cm) in width and 9.5 inches (24 cm) in height. Its weight is 20 lb (9.1 kg). A photograph of the recorder is shown in Fig.1.

3 DETAILED DESCRIPTION

3.1 The tape transport mechanism

The tape deck from an E.M.I. tape recorder type RE.321 is used. It has a permanent magnet, governor controlled, 12V motor; and runs at a tape speed of 7.5 in/sec (19 cm/sec). The original E.M.I. record and replay heads are replaced by a Marriott type U4 four-track head. When 900 ft (270 m) "extra play" 5 in tape spools are used the total recording time is 24 min, while 1200 ft (360 m) "double play" tape spools give a recording time of 32 min.

3.2 Power supply and control system (Fig.2)

The circuit diagram of the power supply and control system is shown in Fig.2.

Eight type HP 2 dry cells are used for the internal power supply for the tape drive motor and recording electronics; the useful life of the battery is 30 min continuous recording. Alternatively the system can be run off an external 12V d.c. supply, the current requirement being 330 mA. A moving coil meter is built into the tape deck; it can be switched to indicate the battery voltage, the bias current, or the recorded signal amplitude for any of the four channels. An electro-mechanical latch switch is fitted so that the pressure on the pinch roller can be relieved when the recorder is not in use. A "test" button can be used to switch on the electronics only and the input attenuator settings can thereby be checked without switching on the tape transport motor. Motor suppressor and battery regulating circuits shown in Fig.3 are included in the power supply system. The tape recorder can be operated either by a local or remote control.

3.3 Signal attenuators and record amplifiers

The input signal attenuators, which were obtained commercially, present a constant impedance of 55 kohms to the signal source, and provide a range of 60 dB attenuation in 3 dB steps.

The four recording amplifiers are built on plug-in circuit cards to simplify servicing. The circuit diagram is shown in Fig.4 and their frequency characteristic is shown in Fig.5. Bias current is derived from the bias oscillator (Fig.6) which operates at a frequency of approximately 50 kc/s (kHz).

3.4 Replay amplifiers

Recorded tapes are replayed on a commercial tape machine fitted with a four track replay head. The circuit diagram and frequency characteristic of the replay amplifiers is shown in Fig.7 and Fig. 8 respectively.

4 PERFORMANCE TESTS

4.1 Frequency range

The record/replay frequency characteristic is shown in Fig.9. The overall response of the system is level between 45 c/s (Hz) and 8 kc/s (kHz) within 3 dB.

4.2 Signal to noise ratio

Recording a 1 kc/s (kHz) signal at maximum amplitude on the tape recorder and replaying on a good quality commercial tape machine gives a signal to noise ratio of 29 dB. For the purpose of this test, maximum signal is arbitrarily defined as that which, upon replay, produces a third harmonic distortion of 3%.

4.3 Harmonic distortion

If a 1 kc/s (kHz) signal 6 dB less than maximum is recorded, then on replay a second harmonic distortion of 1.5% and a third harmonic distortion of 1% are indicated.

4.4 Crosstalk

With a 1 kc/s (kHz) signal recorded on one channel, the ratio between the signals replayed from that channel and from an adjacent channel is 23 dB.

4.5 Flutter

The flutter was measured under a wide range of ground and flight vibration conditions and the results are shown in the appendix.

5 CONCLUSIONS

A recorder has been made which is self-contained and is suited to applications involving multi-channel acoustic measurements, particularly where a portable recording system is required. It has a frequency range from 45 c/s (Hz) to 8 kc/s (kHz) and a maximum recording time of 30 min.

The recorder has been shown to operate adequately in the vibration environment encountered in the HP 115 aircraft.

The level of flutter over a range of conditions was found to be acceptable.

Appendix

ENVIRONMENTAL TEST - VIBRATION

1 Range of tests

1.1 Flutter

The flutter characteristics of the tape recorder were measured for three conditions and by two methods. The three conditions were as follows:-

(i) Recorder stationary i.e. whilst operating on a bench.

(ii) Recorder vibrated to the latest draft form amendment to BSI Spec 2G 100. The random and sinusoidal sections of this specification were used to set up the tests.

(iii) Recorder flown in the HP 115 aircraft.

and the two methods of flutter measurement were:-

(a) A recorded signal of 1.5 kc/s (kHz) was examined on a 6% band width analyser which was tuned so that the frequency of the signal coincided with the steepest part of the analyser filter characteristics. Frequency variations were therefore manifested as amplitude variations, and the peak to peak values of these variations were recorded using a pen recorder.

(b) As a further check on the above method, a 6 kc/s (kHz) signal was recorded on the tape and analysed by means of a McMichael 'Fluttermeter'. This is the standard flutter measuring instrument used by I. & R. Department, R.A.E. The flutter measurement bandwidth was 0-1200 c/s (Hz).

2 Results

2.1 Stationary tests

Signal frequency c/s (Hz)	Method of analysis	Percentage flutter (pk to pk)
1500	Filter characteristics	1.2
6000	McMichael 'Fluttermeter'	0.8

2.2 Vibration tests

2.2.1 Random Excitation

g level	$\frac{1}{3}$ octave filter centre frequency of excitation c/s (Hz)	Signal frequency c/s (Hz)	Percentage flutter (pk to pk)		Method of analysis
			Vertical excitation	Lateral excitation	
0.142	16		1.2	1.3	
0.158	20		1.7	1.7	
0.177	25		1.5	2.2	
0.197	31		4.0	1.3	
0.224	40		2.0-4.4	2.2	
0.250	50		2.0	2.0	
0.282	60		1.7	1.3	Using filter character-istics (see sect. 1(a))
0.317	80	1500	1.4	1.2	
0.354	100		2.2	1.2	
0.396	125		1.5	1.4	
0.497	160		1.6	1.3	
0.500	200		1.4	2.0	
0.558	250		1.6	6.0	
0.628	315		1.6	4.4	
0.708	400		1.4	12	
0.790	500		1.4	12	
1.06 to 2.82	*low freq. medium freq. high freq. (over range 16-500 c/s (Hz))	6000	1.2 1.5 2.0	- - -	Using McMichael 'Fluttermeter'

*Method of analysis did not permit exact measurement of frequency.

2.2.2 Sinusoidal excitation

Type of test	Level of excitation 'g'	Frequency of excitation c/s (Hz)	Signal frequency c/s (Hz)	Percentage flutter (pk to pk)	
				Vertical excitation	Lateral excitation
Sinusoidal at resonant frequencies	0.45 0.50 1.00	150 200 590	1500	6 - -	- 1.4 1.0
Sweep frequency)* *1 oct. per min	1.06-2.82	16-500	1500	7-10	1.2-2.6

2.3 Flight tests

Using the filter characteristic technique the flutter of a 200 c/s (Hz) signal recorded in flight was found to be as follows:-

Speed Kt	Speed m/s	Percentage flutter	Duration of recording min
170	87.5	1.3	1
120	61.8	1.0	1
85	43.8	1.0	1

The recorder was bolted to tray which in turn was bolted rigidly to the aircraft floor. The weather during flight was very turbulent, resulting in severe vibration levels for this aircraft.

3 Conclusions

Close agreement exists between two methods of measuring the percentage flutter on the recorder. The measured values show that the recorder will operate satisfactorily under most flight conditions. This is supported by the results of flight measurements of flutter when installed in the HP 115 aircraft.

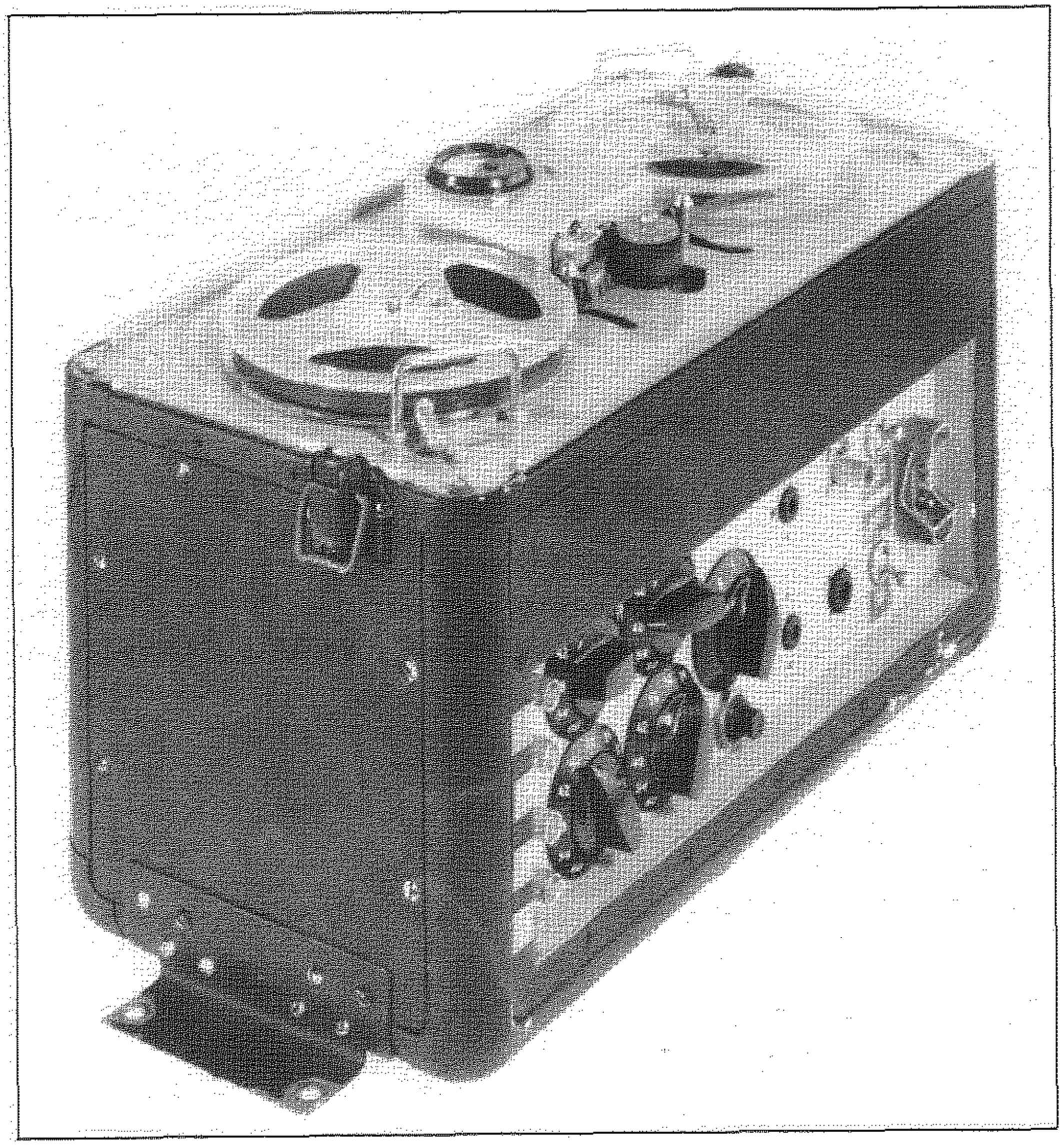


Fig.1 Four channel tape recorder

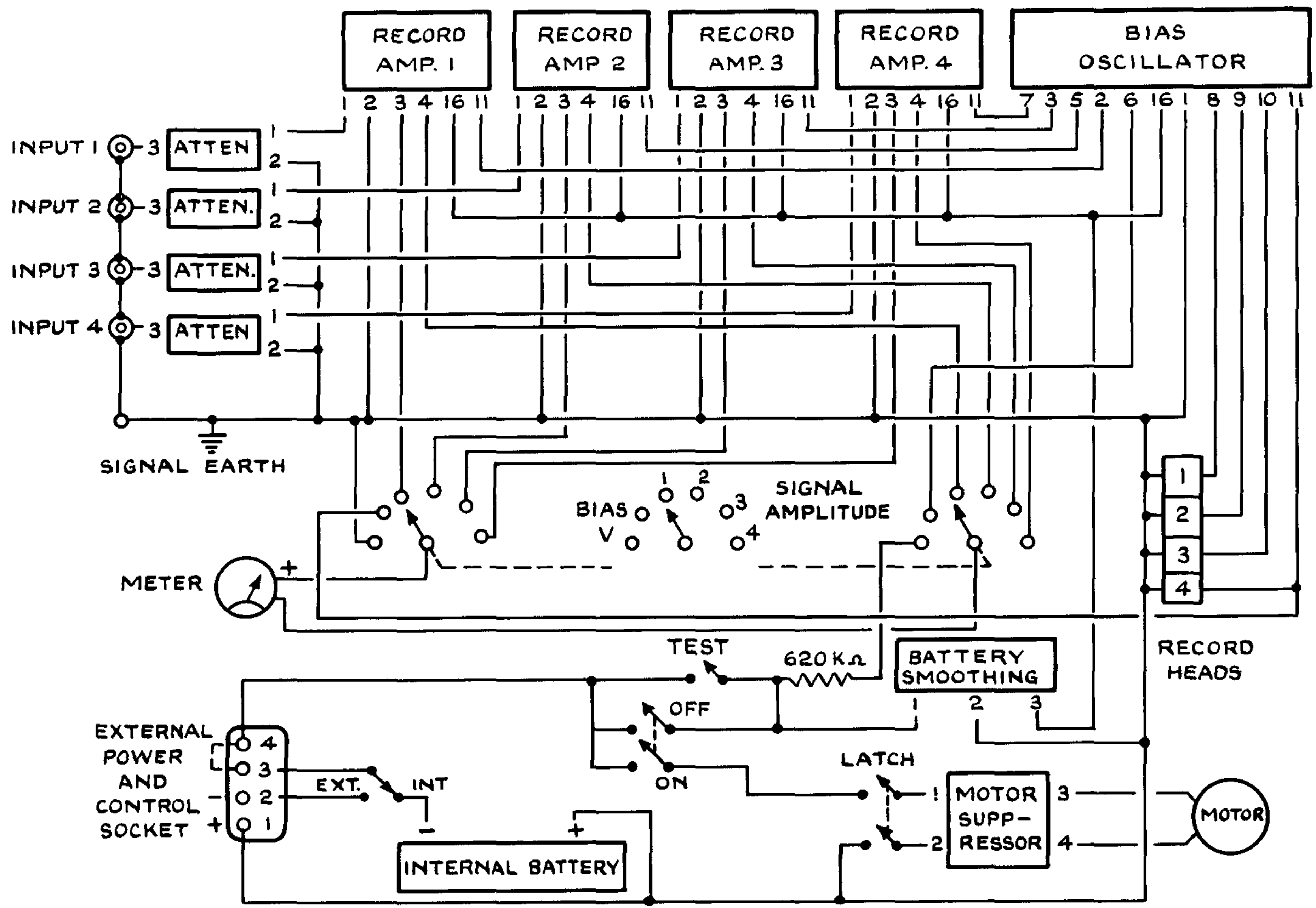
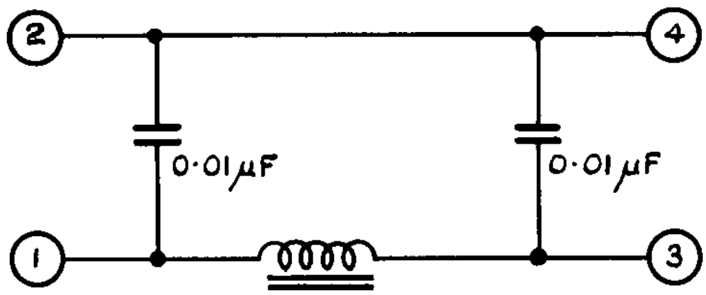
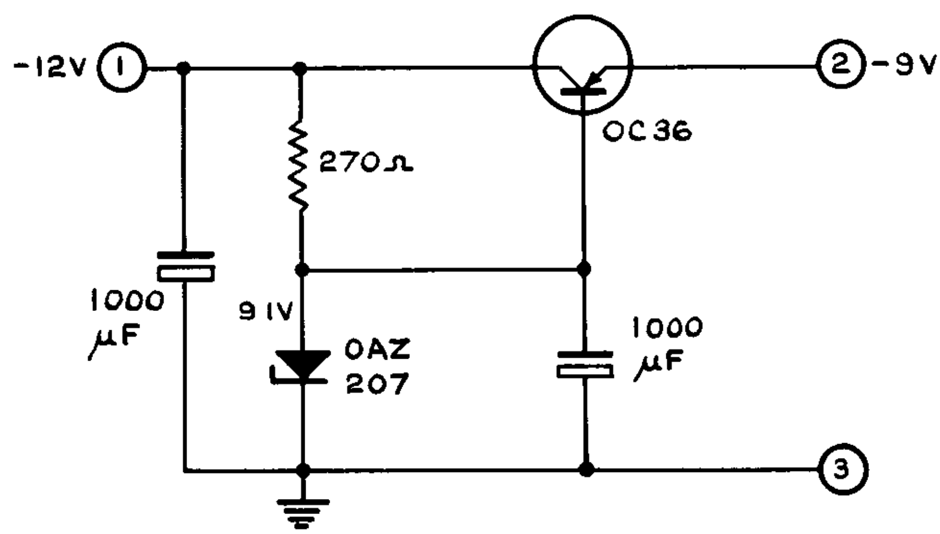


FIG. 2 POWER AND CONTROL SYSTEM



MOTOR SUPPRESSOR



BATTERY REGULATOR

FIG.3 MOTOR SUPPRESSOR AND BATTERY REGULATOR

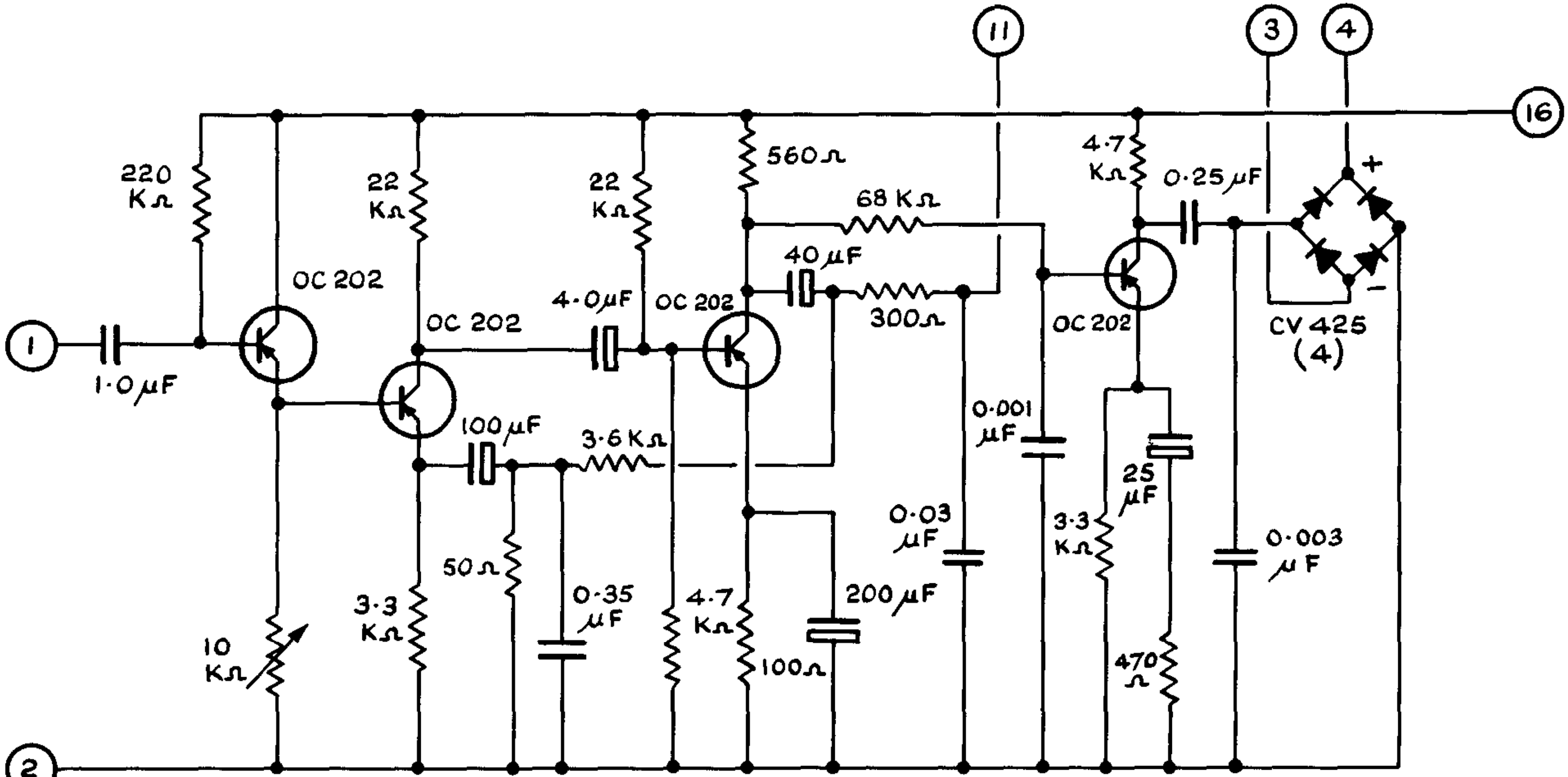


FIG. 4 RECORD AMPLIFIER

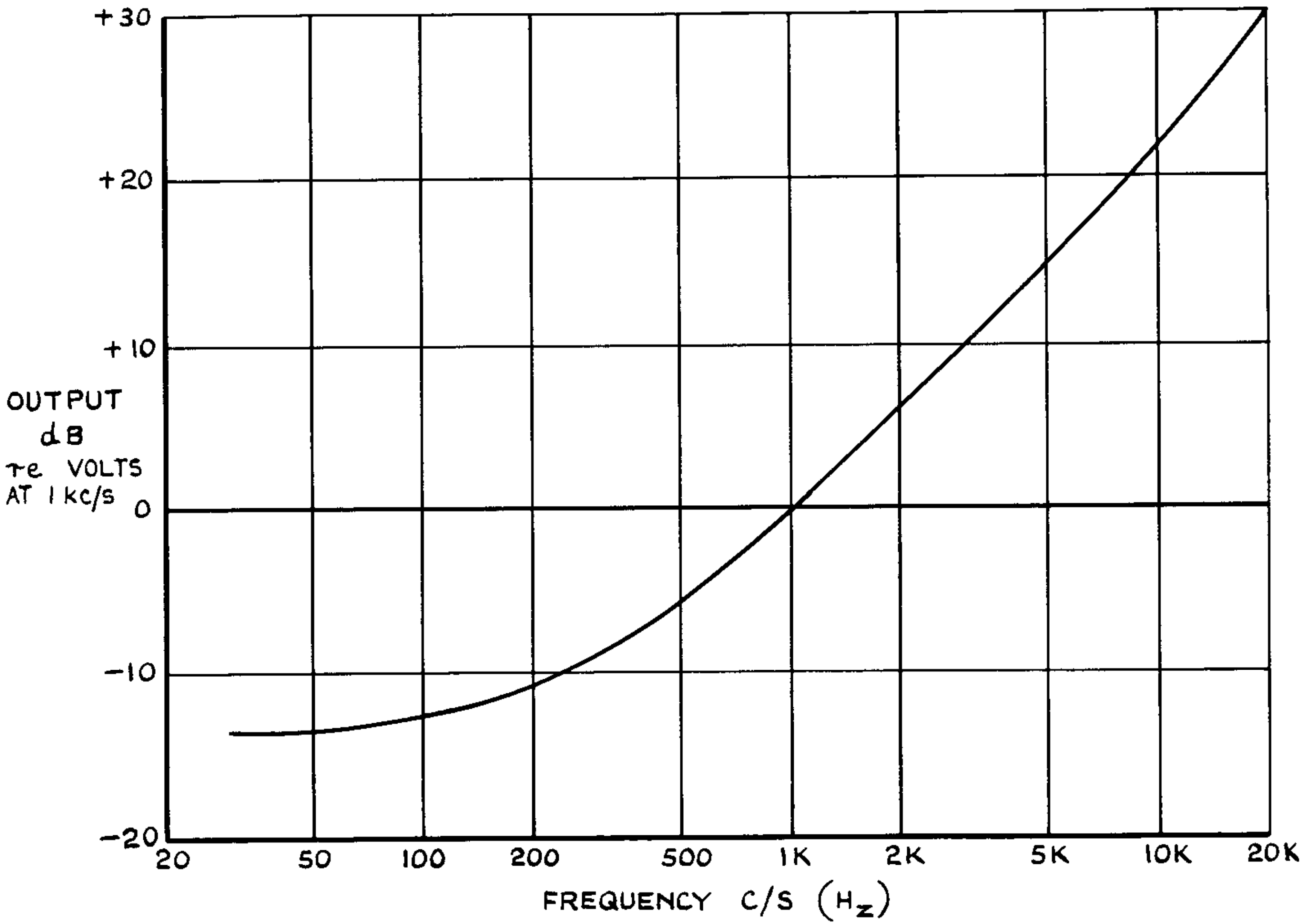


FIG. 5 RECORD AMPLIFIER CHARACTERISTIC

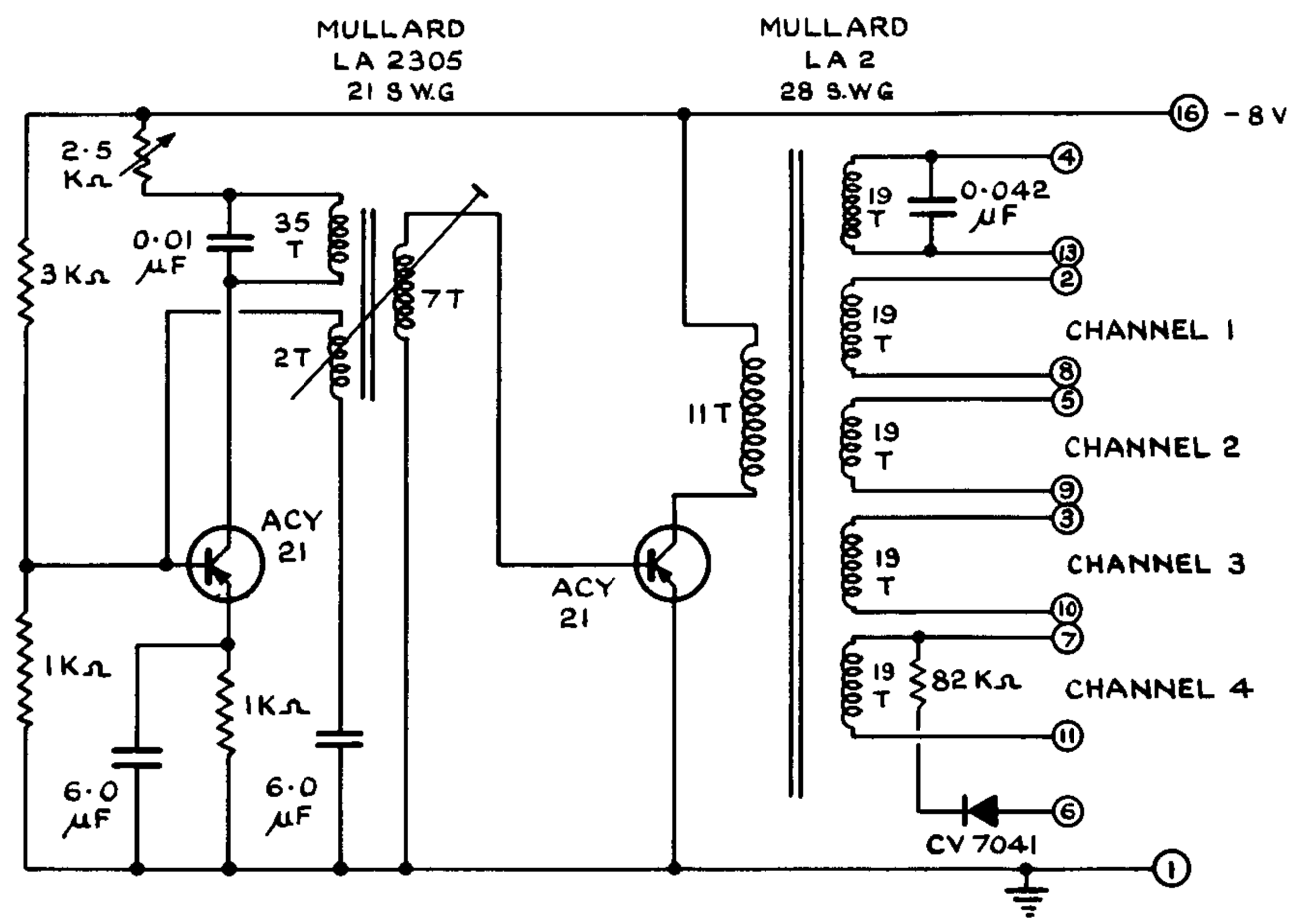


FIG. 6 BIAS OSCILLATOR

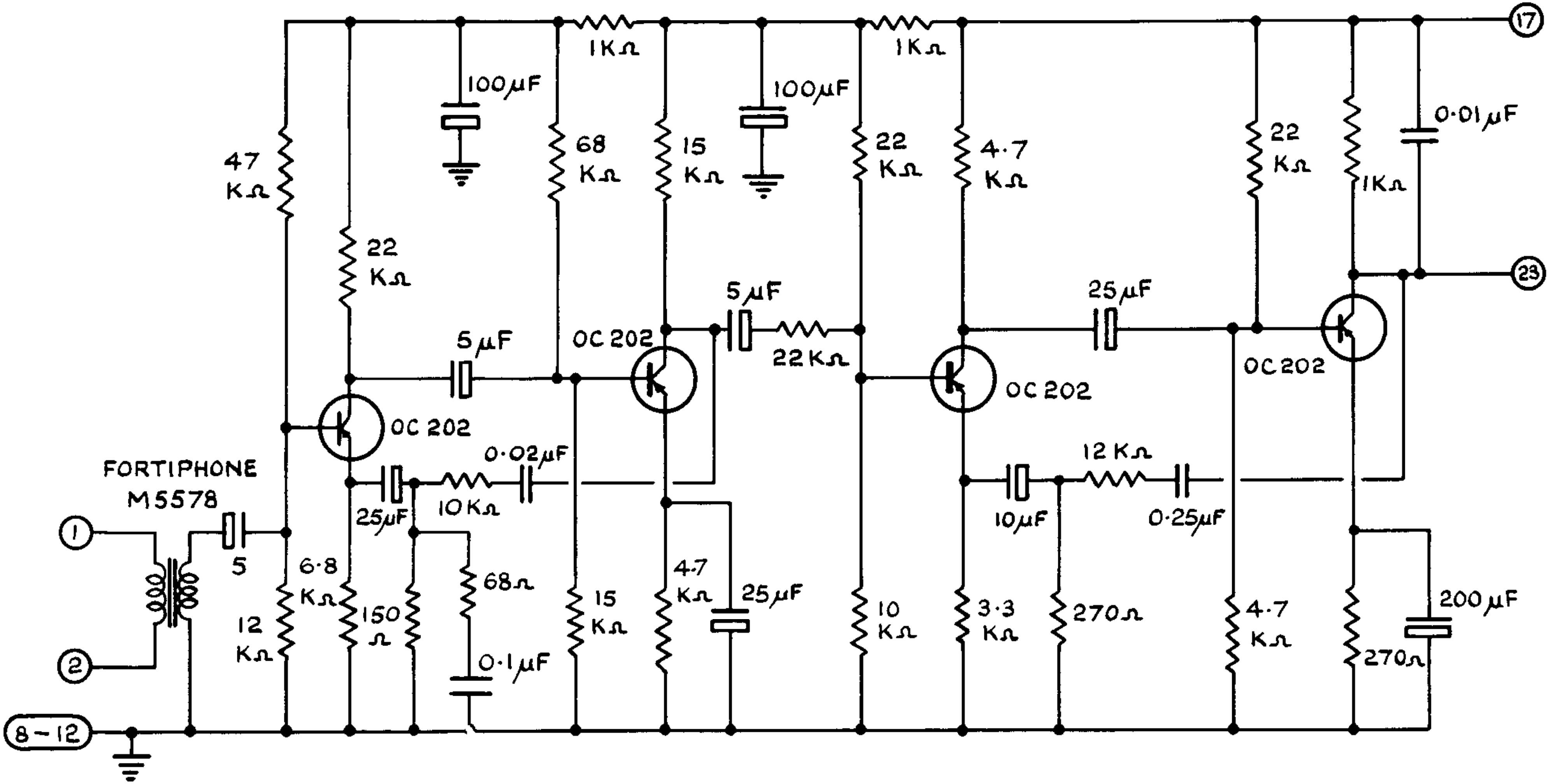


FIG. 7 REPLAY AMPLIFIER

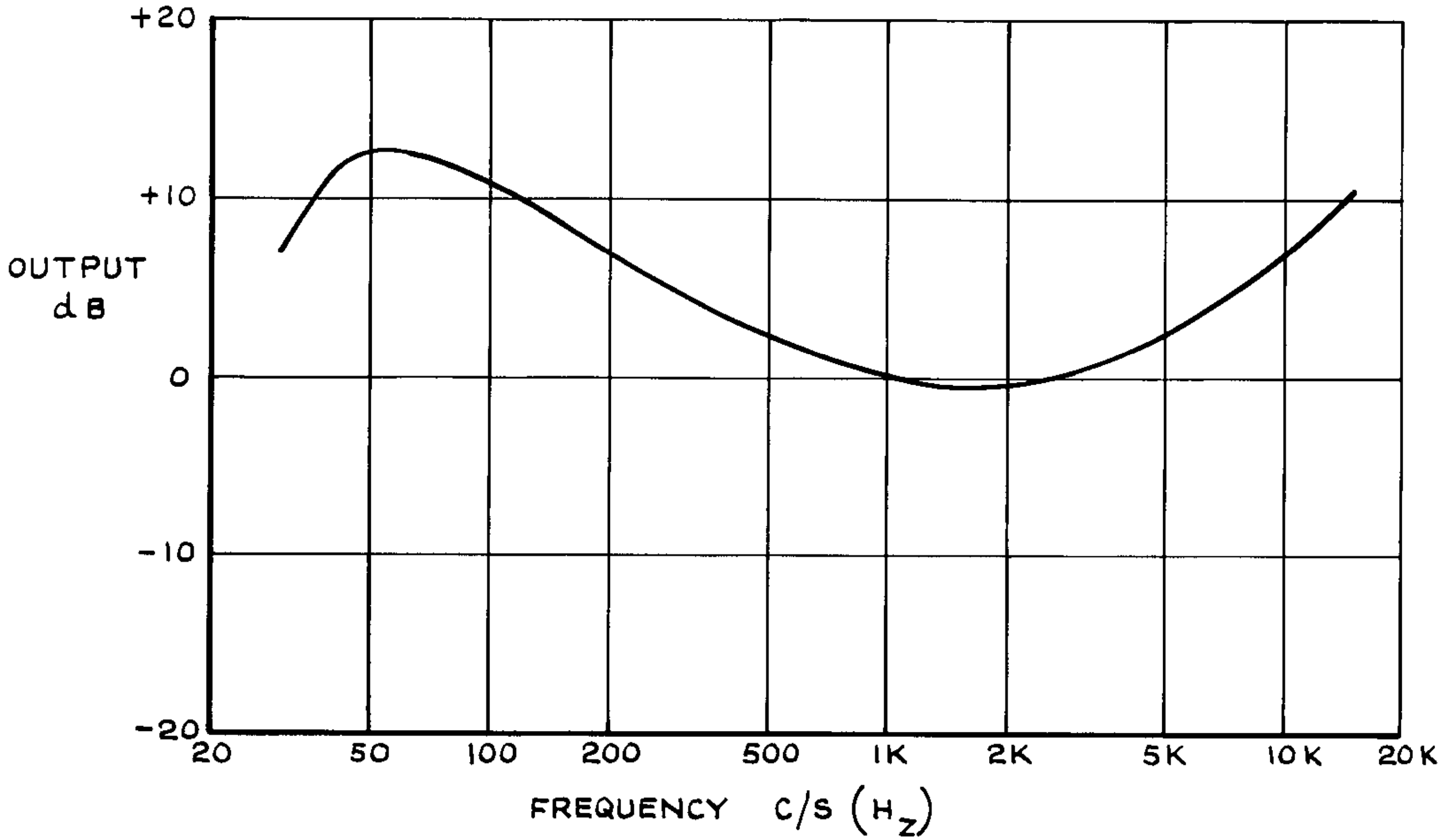


FIG. 8 REPLAY AMPLIFIER CHARACTERISTIC

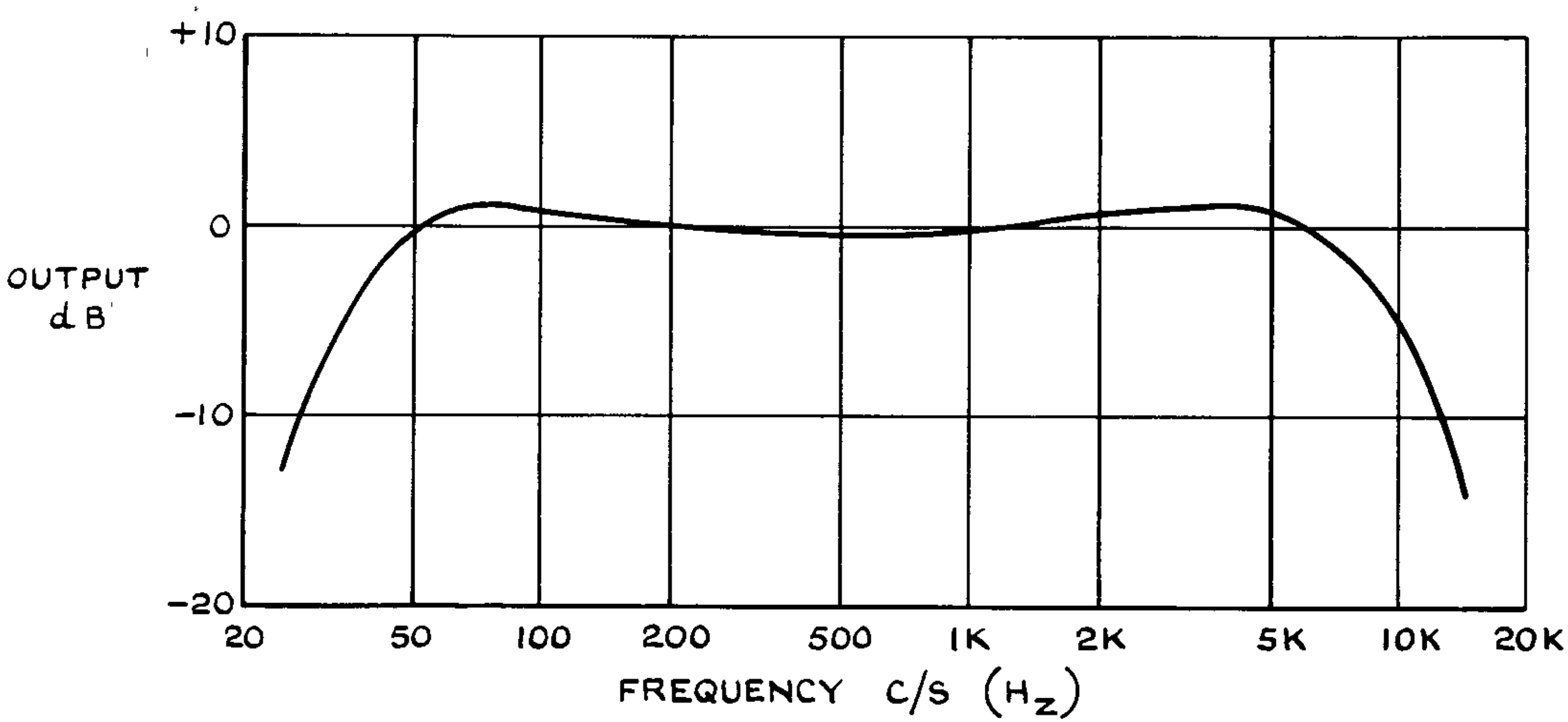


FIG. 9 RECORD / REPLAY CHARACTERISTICS

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