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UNIVERSITY OF MICHIGAN
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WIDE-RANGE TUNING METHODS AND TECHNIQUES APPLICABLE TO SEARCH RECEIVERS

QUARTERLY PROGRESS REPORT NO. 13, TASK ORDER NO. EDG-4
Period Covering July 1, 1954 to September 30, 1954

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ABSTRACT

The progress of the Electronic Defense Group on Task EDG-4 is reviewed for the quarter ending September 30, 1954. Four Technical reports were issued during the quarter. The panoramic display unit (PANDU) has been completed, and tests of front end designs of electric-tuned swept receivers have begun. The construction of the Butterfly Loop Automatic Recorder (BLARE) is nearing completion. Better quality equipment for the voltage-tunable magnetron tests is being assembled. The objectives of the quarter have been accomplished, and work is proceeding satisfactorily.

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1. PURPOSE

This report reviews the progress made by the Electronic Defense Group in the study of wide-range tuning methods and techniques applicable to search receivers during the third quarter of 1954.

2. PUBLICATIONS AND REPORTS

Four technical reports were issued during the quarter. These are as follows: Technical Report No. 31, Interim Report on Ferroelectric Materials and Their Applications, by Howard Diamond and L. W. Orr, July, 1954; Technical Report No. 32, Ferromagnetic and Ferroelectric Tuning, by L. W. Orr, July, 1954; Technical Report No. 33, The Negative Capacitor Amplifier, by L. C. Beavis, August, 1954; Technical Report No. 37, Magnetic Modulator Design Employing Mu Surfaces for Ferrites, by L. W. Orr, September, 1954.

3. FACTUAL DATA

3.1 Use of Ferromagnetic and Ferroelectric Materials in the Tuning of RF Components

3.1.1 Ferromagnetic Materials (L. W. Orr) Equipment to facilitate the measurement of μ, and Q of the ferrite cores produced by Task 6 while applying a

D. C. magnetic field, is now in the design stage.

There is a need for a type of spot-check measurement to rapidly determine the suitability of a new core as a circuit element in a magnetic tuned search receiver. The equipment is being designed with this in mind, and a suitable spot-check schedule for routine evaluation of each core will be worked out.

3.1.2 Ferromagnetic and Ferroelectric Tuning (L. W. Orr) The results of a comparison study of ferromagnetic and ferroelectric tuning methods and materials are embodied in Technical Report No. 32, issued during the last quarter. It is concluded that at this time, magnetic tuning is a more satisfactory method for most purposes because it has been more fully developed. However, this does not preclude the possibility of developing a competitive tuning facility with new ferroelectric ceramics and new circuit techniques.

3.1.3 Ferroelectric Materials and Applications (H. Diamond) The results of a continuing study of ferroelectric materials were reported in detail in Technical Report No. 31 issued during the quarter. Both single crystals of pure barium titanate and titanate ceramic capacitors were investigated. The tuning ranges obtained for eight test oscillators using electric tuning extended from 38 to 375 megacycles. A tuning ratio of 2:1 was easily obtained at the lower frequencies, while a ratio of only 1.027:1 was obtained at the highest frequency using an ultra-audion circuit. It is hoped that this tuning range can be increased by modifying the circuit.

3.1.4 Negative Capacity Amplifier (L. W. Orr and L. C. Beavis) This circuit furnishes a method of reducing the minimum capacity of another circuit and thus improves the tuning ratio of an electric tuned resonant circuit. It is possible to make a reduction in capacity up to 65$\mu\mu$f for operating frequencies up to about 3 mc. provided the amplitude of oscillations is not in excess of a few rms volts. The results of this investigation are fully described in Technical Report No. 33.

3.1.5 BLARE (Butterfly Loop Automatic REcorder)(L. W. Orr and M. Winsnes) This facility will furnish an automatic plot of the dielectric constant vs. electric field of a ferroelectric sample. It will permit a large volume of data to be obtained in a relatively short interval on the many types of ferroelectric ceramics presently available, and over various temperature ranges.

Fig. 1 shows a perspective view of the completed equipment. Construction on the unit has begun, and the Moseley X-Y recorder has just been delivered at this writing.

A block diagram of the system is shown in Fig. 2. The specimen (3) is excited by a 1000 cycle generator (1). The current flowing in resistor R_2 is equal to $A\frac{dp}{dt}$, the specimen area times the rate of change of polarization p of the specimen with time. This current is thus proportional to the dielectric constant, ϵ, at any particular value of applied electric field, E.

The voltage across R_2 is amplified and detected by the amplifier and detector 4 whose dc output is recorded by the pen of the X-Y recorder (5). The pen displacement is therefore proportional to ϵ, the dielectric constant. Standard capacitors built into the equipment will permit a direct method of calibration.

The variable electric field applied to the specimen is furnished by the reversing, motor-driven d-c supply (2). This has a uniform voltage change of 200 volts per second maximum from +1000 volts to -1000 volts, so that a triangular wave is generated with a half-period of 10 seconds. By altering the belt drive, a wave with a half-period of 40 seconds is also available.

The variable voltage E from the supply(2)is isolated from the specimen by resistor R_1. This voltage is also applied to the drum input of the X-Y recorder

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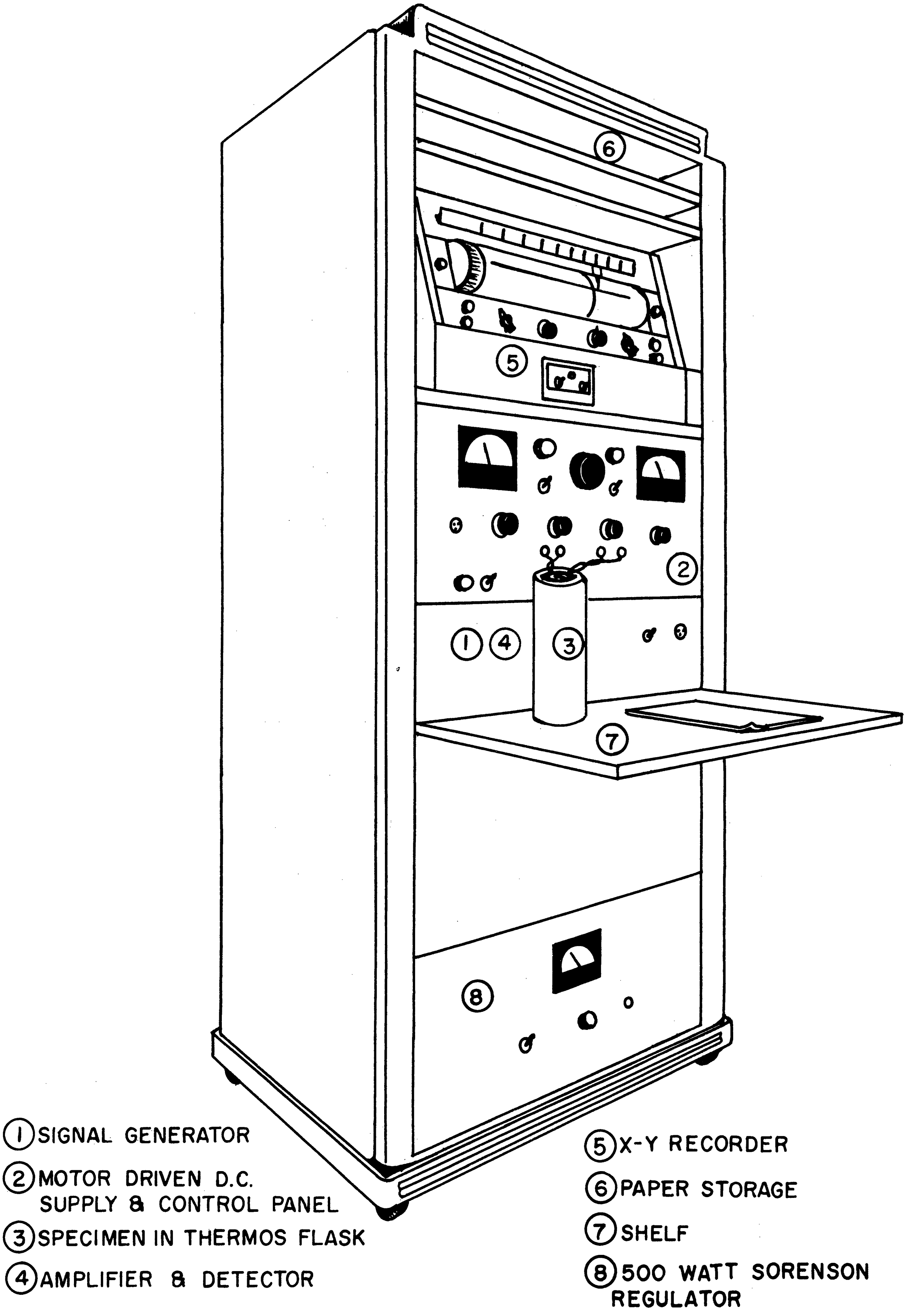

FIG. 1
BLARE
(BUTTERFLY LOOP AUTOMATIC RECORDER)

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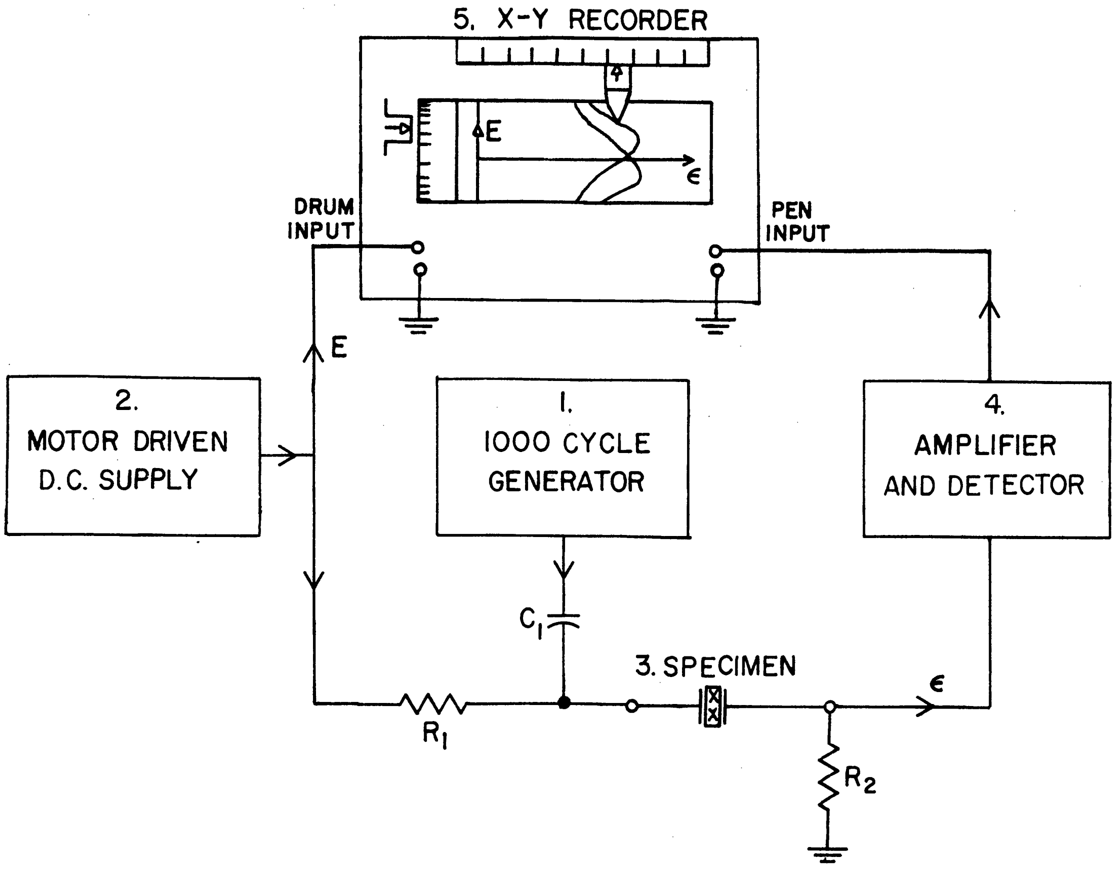

FIG. 2

BLOCK DIAGRAM OF BLARE

which produces an automatic plot of the ϵ-E curve, or Butterfly Loop of the specimen.

A heater control and thermos flask are provided (see Fig. 1) to operate the specimen at elevated temperatures.

3.1.6 PANDU (PANoramic Display Unit)(W. J. Lindsay and T. W. Butler, Jr.) Construction of a panoramic display unit has been completed in conformance to Sections 3.1.6 and 3.1.7 of Quarterly Progress Report No. 12. This unit will serve as a versatile testing facility for front ends of electric-tuned search receivers.

Fig. 3 shows an artist's perspective of the rack mounted unit. For purposes of identification, the units of the block diagram in Fig. 4 are numbered to correspond to those in Fig. 3.

Unit No. 6 is the electric-tuned front end assembly under test. It may contain a tuned r.f. stage, oscillator, and mixer. Unit No. 1 contains the 60 cycle sweep and high voltage bias supplies. There are three identical power units in this supply, one each for the r.f., oscillator, and mixer stages. Each of these power units consists of superimposed, variable, a.c. and d.c. voltage units. The a.c. and d.c. levels may be individually controlled in the range of 0 to 1000 volts. This arrangement is desirable for tracking studies, because it becomes necessary to change the d.c. bias and a.c. sweep levels applied to the voltage sensitive capacitors in each of the three tuned circuits involved.

The mixer output of the front end assembly feeds Unit No. 4, the 20 MC I.F. amplifier and detector. The schematic of the IF strip and detector is shown in Fig. 5. The output of the detector is coupled to the Y-axis input of the oscilloscope, Unit No. 2. The X-axis input of the oscilloscope is driven by the 60 cycle sweep voltage from the power supply Unit No. 1.

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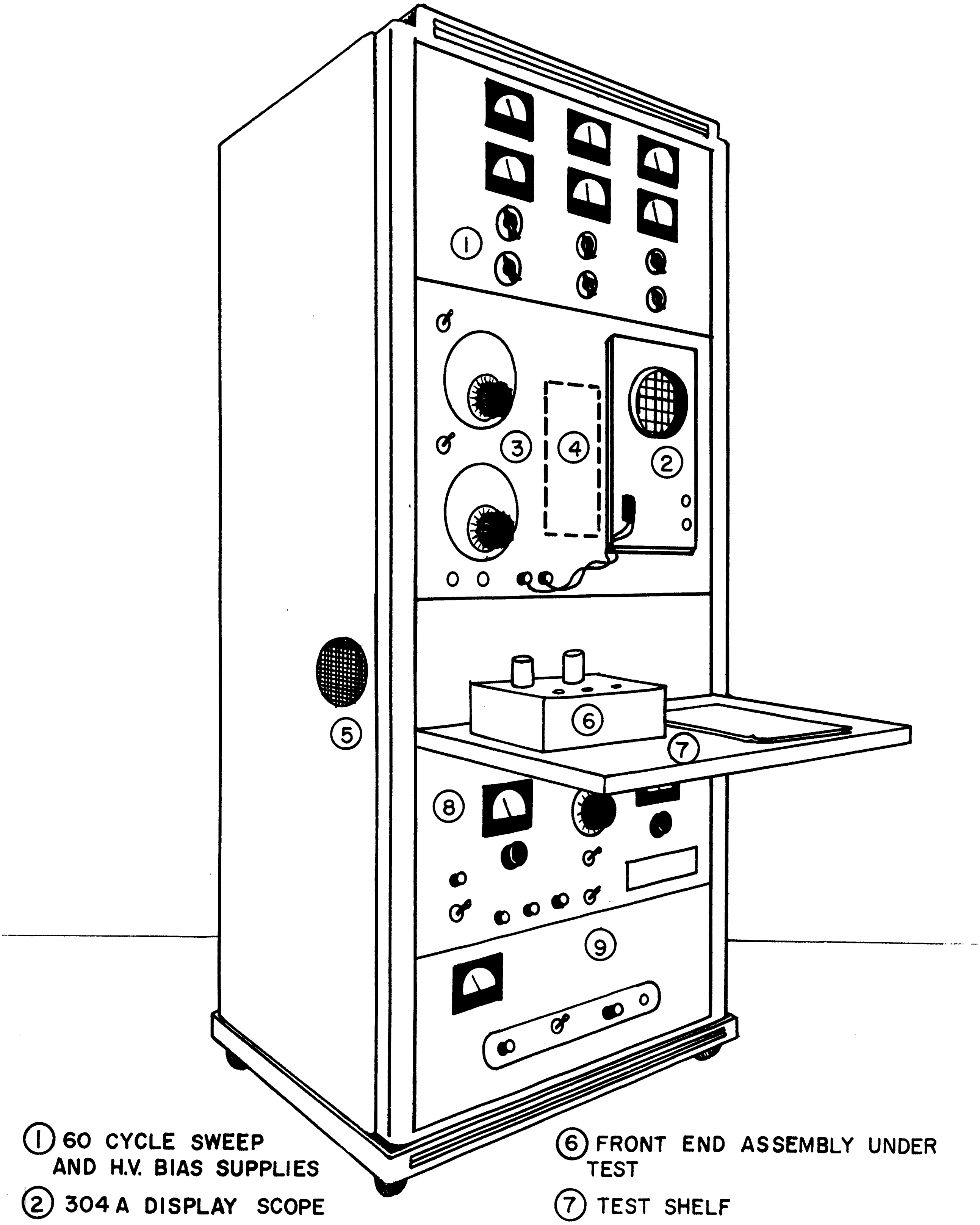

① 60 CYCLE SWEEP AND H.V. BIAS SUPPLIES

② 304 A DISPLAY SCOPE

③ TEST SIGNAL GENERATORS

④ 20MC I.F. STRIP AND DETECTOR

⑤ COOLING FAN

⑥ FRONT END ASSEMBLY UNDER TEST

⑦ TEST SHELF

⑧ 300 V 200MA DC REGULATED POWER SUPPLY 6.3V 10A

⑨ 1000 WATT SORENSEN REGULATOR

PANDU
PANORAMIC DISPLAY UNIT

FIG. 3

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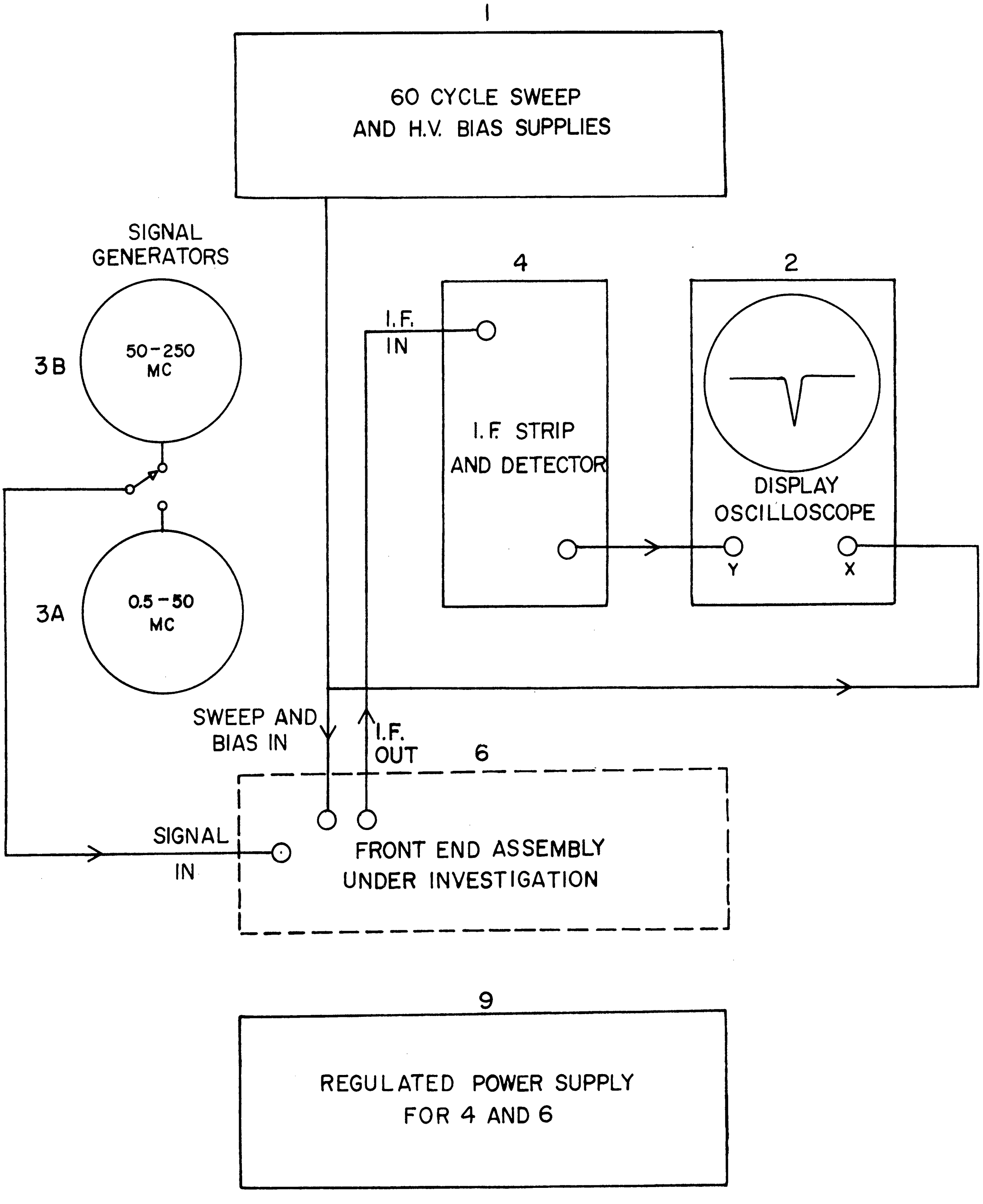
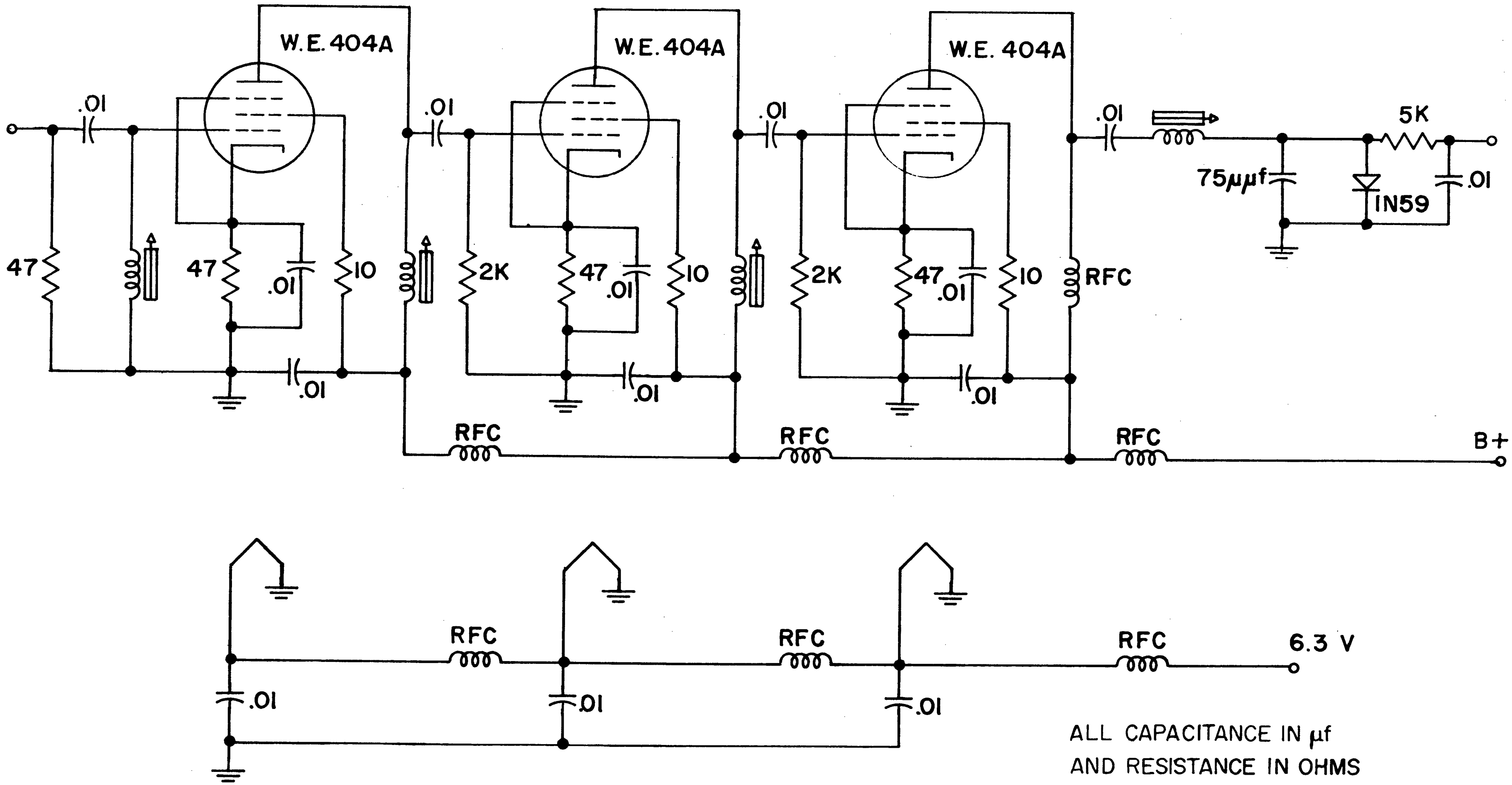


FIG. 4

BLOCK DIAGRAM OF PANDU



ALL CAPACITANCE IN μf
AND RESISTANCE IN OHMS
UNLESS OTHERWISE SPECIFIED

FIG. 5

PANDU I.F. STRIP AND DETECTOR

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Test signals are available from the two signal generators,Units 3A and 3B. Unit 3A covers 0.5 to 50 MC. Unit 3B covers 50 to 250 MC.

Unit No. 8 is a Hewlett-Packard regulated power supply for the front end assembly and the IF amplifier.

Unit No. 9 is a Sorenson AC line voltage regulator from which the entire unit is powered.

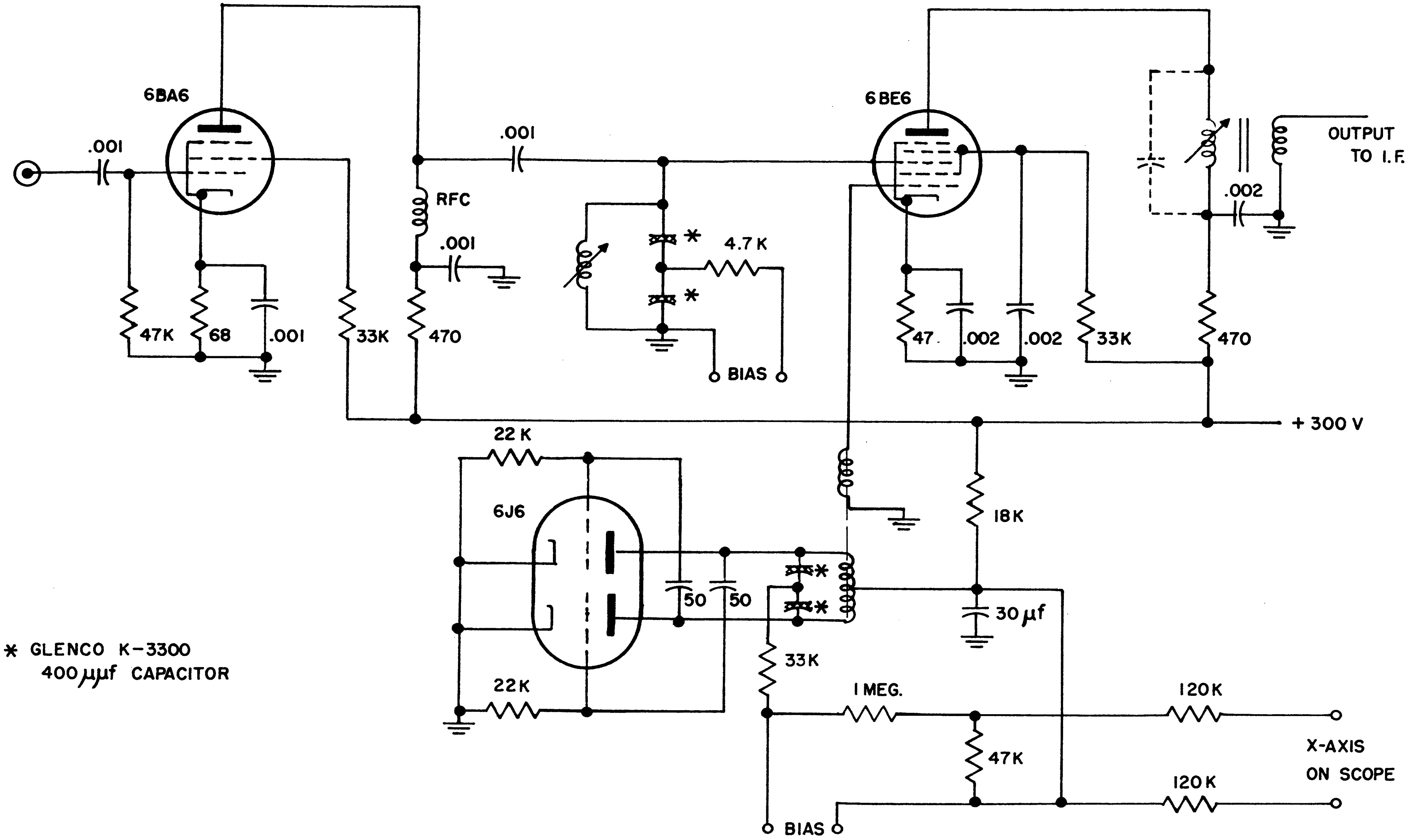
Unit No. 5 is a blower for ventilating the voltage tuned front end assembly.

An electric-tuned front end assembly No. FE-1, has been constructed for the 27 to 55 MC range and some preliminary tests made on it. The oscillator and mixer circuits have been swept over their respective frequency ranges and roughly tracked.

The schematic of the FE-1 front end assembly is shown in Fig. 6. The RF and mixer circuits were adapted from the RCA tube handbook. The push-pull oscillator circuit was used because it works well at the frequencies involved, and it is convenient to apply the bias voltages to the push-pull circuit.

During the testing of FE-1, which tuned from 27 to 55 MC, several things came to light which may be of interest. It became apparent that some sort of control over the output of the two signal generators, units 3A and 3B, was needed. The output level is considerably higher than needed, and is not uniform over the frequency range. An AVC circuit is being designed to regulate the output over the frequency range, and attenuators are to be purchased so the output level may be changed in uniform steps.

One effect observed on the scope during the tracking studies was the appearance of double pips slightly displaced at the signal acceptance position. This has been attributed principally to the polarization lag of the voltage sensi-



* GLENCO K-3300
400 μμf CAPACITOR

FIGURE 6

SCHEMATIC OF FE-I FRONT END ASSEMBLY

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tive capacitors. A blanking circuit for the upsweep is being added to the scope.

The tracking problem is being approached from the standpoint of using low Q circuits initially and gradually increasing the Q until the practical limit is reached.

The ferroelectric capacitors are sensitive to temperature changes, consequently it was felt that some measure should be taken to stabilize the units with regard to temperature variations. The blower, Unit No. 5 performs this function. The blower ventilates the front end assembly, keeping all three tuned circuits at approximately the same temperature.

3.1.7 Ferroelectric Tests at VHF (H. Diamond) Preparation for conducting VHF Q-meter measurements on ferroelectric specimens are being made. The variation of Q and C as the electric field is applied will be measured on specimens from 100 to 500 MC, and results compared with corresponding data taken at lower frequencies.

3.1.8 Program for Next Interval (L. W. Orr) The equipment described in 3.1.1 will be constructed for testing magnetic cores, and a testing schedule worked out. BLARE, described in Section 3.1.5 will be completed, and an intensive study of Butterfly Loops will be started. The applicability of BLARE to the automatic plotting of P-E Loops will be investigated.

The PANDU Program for the next interval will consist of further tracking studies and packaging work in the 27-55 MC range. Initial tests on a modified front end assembly (FE-2) have shown considerable improvement in operation. It is intended that the studies shall be projected to the higher frequency ranges. Some initial work has been done on a unit for the 150 MC range. This will be continued during the next period.

The Q-meter measurements at VHF on ferroelectric specimens discussed in

3.1.7 will be started. A technical report summarizing the work on Barkhausen noise in ferroelectric ceramics will be prepared in the near future.

3.2 Investigation of Microwave Local Oscillator

3.2.1 Voltage Tunable Magnetrons (R. W. Bradley) Two systems for measuring the off-carrier noise of the magnetron were described in Quarterly Progress Report No. 12. Testing of the individual components of the proposed systems has been conducted. Progress has been slowed by the difficulty of obtaining an IF amplifier which has a noise figure low enough to allow detection of the signals under investigation. Measurements of off-carrier noise are difficult because of the relative magnitudes of the carrier power and off-carrier noise power. Hence, the skirts of the IF amplifier pass band must have sufficient attenuation to keep the contribution of the carrier to the amplifier output small. The communications receivers proposed for this application have proven inadequate. A commercially built 30 MC IF amplifier of 100 db gain has been ordered. A crystal mixer and a standard microwave noise source were received during the quarter.

3.2.2 Program for Next Interval During the next quarter work on the IF amplifiers will be continued. It appears to be the biggest obstacle to completing the system.

4. Conclusion

The objectives set for the quarter ending September 30 have been met, and all programs appear to be progressing satisfactorily.

5. Program for Next Interval

This has been outlined above in Sections 3.1.6 and 3.2.2.

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