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APPLICATION NOTE No. 43

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APPLICATION NOTE
ON
CATHODE-RAY CURVE-TRACING APPARATUS
FOR
ALIGNING TUNED CIRCUITS

"Visuals" or curve-tracing devices for showing the resonance curves of the intermediate- or radio-frequency stages of broadcast receivers have been in use for some time. Some manufacturers have installed enough "Visuals" to align their entire production. Others have installed one or more for aligning part of the production and for checking the work of aligners equipped with meter indicators.

The "Visual" is particularly useful where coupling is such that a double-peaked resonance curve is obtained, since the depth of the valley between the peaks is difficult to determine unless a plot of the curve can be examined. Such a plot is, of course, constantly before the "Visual" aligner so that the effect of coupling or tuning adjustments can be observed during the adjusting process. However, the cost of these curve-tracing devices has in many instances made their use impracticable and has made it necessary to resort to slower methods of checking the design and production of the intermediates. In contrast to high-priced apparatus employing the string galvanometer, cathode-ray apparatus is comparatively inexpensive and will give better results.

Some of the advantages of a cathode-ray "Visual" over the string-galvanometer type are:

1. The trace is more brilliant and does not require an awkward hood for observations in daylight.

2. Overload does not damage the apparatus but merely causes the beam to deflect off the screen.

3. The apparatus can be made portable.

4. The cost of the apparatus is low.

A resonance curve tracer employing the type 906 cathode-ray tube has been set up and operated in the laboratory of the RCA Radiotron Co. This device is designed to cover a range of intermediate frequencies of 100 kc to 500 kc and has an amplifier-detector section which is practically flat over the entire range. Since it is believed that a "Visual" of this type will be of distinct value to many laboratories as well as to manufacturers and service men who desire to improve their testing facilities, a detailed description of the instrument is given in this NOTE. Figure 1 is the schematic circuit diagram while Figure 2 shows the functional layout and a suggested arrangement for a portable resonance curve tracer. It should be borne in mind that the principles and methods involved in this application can be applied to obtain the curves of any form of tuned circuit and that the frequency range is not limited to the 100-500 kc of the apparatus illustrated.

A resonance curve is a plot of the voltage output of a tuned stage for a given frequency band. To obtain this curve, it is necessary to have a voltage source, which in this instance is the oscillator T_2 of Figure 1, and to have a source of variable frequency covering a range which extends above and below the resonant frequency. The frequency variation to sweep across the frequency range of the tuned circuit can be accomplished manually by hand manipulation of a condenser or it can be speeded up to thirty times a second as is done in this case by means of an 1800 RPM motor. The fluctuating output voltage of the stage is then amplified, rectified, and again amplified, and finally applied to one set of the deflecting plates of a cathode-ray tube. The other set of deflecting plates is supplied with the sweep-frequency voltage.

The frequency sweep is produced by a motor of about 1/20 hp or more driving a rotating condenser C_2 of maximum capacitance of 0.00035 μf. A range switch S_2 connects different values of capacitance C_3, C_4, C_5, etc., in series with C_2 to adjust the sweep for different frequency ranges. The oscillator is tuned by adjusting C_1.

A contactor on the motor shaft controls the linear-sweep voltage by periodically short-circuiting condenser C_7. Condenser C_7 charges linearly with time during the half revolution that condenser C_2 sweeps the frequency. During the remaining half revolution, condenser C_7 is short-circuited and C_2 returns to the initial position.

The rheostat P_3 in the cathode circuit of Tube T_1 controls the rate of charge of condenser C_7. When P_3 is properly adjusted, the contactor on the motor causes the voltage of condenser C_7 to return to zero somewhat before the condenser becomes fully charged. When P_3 is adjusted for too slow a charging rate, the sweep, as viewed on the screen of the cathode-ray tube, returns to zero before the full width of the screen has been traversed. On the other hand, if P_3 is adjusted so that the charging rate is too high, the sweep terminates with the condenser fully charged before the contactor has returned it to zero. Considerable distortion of the resonance curve traced on the screen results from this latter adjustment due to non-linearity at the end of the sweep.

The proper adjustment of P_3 causes a full sweep across the screen without any bright spot occurring at the end of the sweep. The appearance of a bright spot is due to the beam remaining in one position for a greater length of time than in other positions. A bright spot should appear at the beginning of the sweep since the beam remains there for one-half of the cycle. At the end of the sweep, no spot should appear when P_3 is properly adjusted.

The centering of the pattern on the screen is accomplished by adjusting the knob of potentiometer P_4.

The frequency-range switch S_2 and the tuning condenser C_1 should be adjusted so that the resonance characteristic appears in the center of the sweep on the screen. As condenser C_1 is varied, the resonance characteristic is shifted along the sweep axis. The best value of C_1 is that which centers the resonance curve on the sweep range.

The input to the grid of the i-f stage to be tested is connected to the contact terminal of potentiometer P_5. The test signal can be adjusted by means of P_5 to give a suitable height of resonance curve. The range switch S_3 reduces the signal when an overall test of two or more i-f stages is made.

When intermediates are to be aligned, the output voltage from the plate of the tube following the i-f stage is connected through a blocking condenser in series with a low resistance of approximately 1000 ohms to the amplifier circuit as shown in Figure 2. When the tube following the i-f stage is a diode detector, the resistance can be eliminated. In this case, the input lead is connected to the high-potential end of the diode load resistance. Sufficient i-f voltage is generally present across the by-pass condenser of the diode load resistor to give a deflection on the cathode-ray tube. Since the diode load is by-passed, there is no capacity effect from the connecting leads and the resonance adjustment does not change with their removal. The resonance curve obtained on the screen of the cathode-ray tube represents audio frequency and, hence, appears not as a modulation envelope but as a single-line curve above the zero axis.

The constants of the oscillator circuit will depend somewhat upon the arrangement of the wiring, distributed capacitance, etc. In order to realize the full operating range of frequencies from 100 kc to 500 kc, it is important to have tuning condensers with low minimum capacitances, and to keep wiring capacitances at a minimum. The exact values for the constants of the oscillator circuit are best determined by actual test after the apparatus is in operation. Suggested values for these constants are as follows:

$C_1 = 150$ μμf maximum
$C_2 = 350$ μμf " (Ball-bearing type)
$C_3 = 0.00005$ μf
$C_4 = 0.00005$ μf
$C_5 = 0.0001$ μf
$C_6 = 0.00035$ μf
$L_1 = 2.0$ millihenries
$L_2 = 2.0$ "
$L_3 = 5.0$ "

The inductances are closely coupled.

Desirable characteristics for the oscillator are uniform voltage output especially throughout the sweep range, and frequency change proportional to the angular rotation of the frequency-sweep condenser C_2. This condenser should preferably be one of the straight-line-frequency type, although an ordinary semi-circular plate condenser is easier to balance mechanically in order to avoid vibration. The latter, however, is satisfactory for the usual alignment purposes; that is, with it no distortion of the resonance curve is noticeable to the eye, although it could not be depended upon for precise measurements.

Care should be taken to select a variable condenser that is rugged in construction and revolves on ball bearings. Contact with the rotor can be made by means of a brush or other smooth-riding pressure contact on the condenser shaft. The short-circuiting contactor is a standard automotive ignition breaker. It is operated by a cam on the motor shaft. A bakelite drum having a metal insert in its periphery can be used as a shorting device, if it is desired.

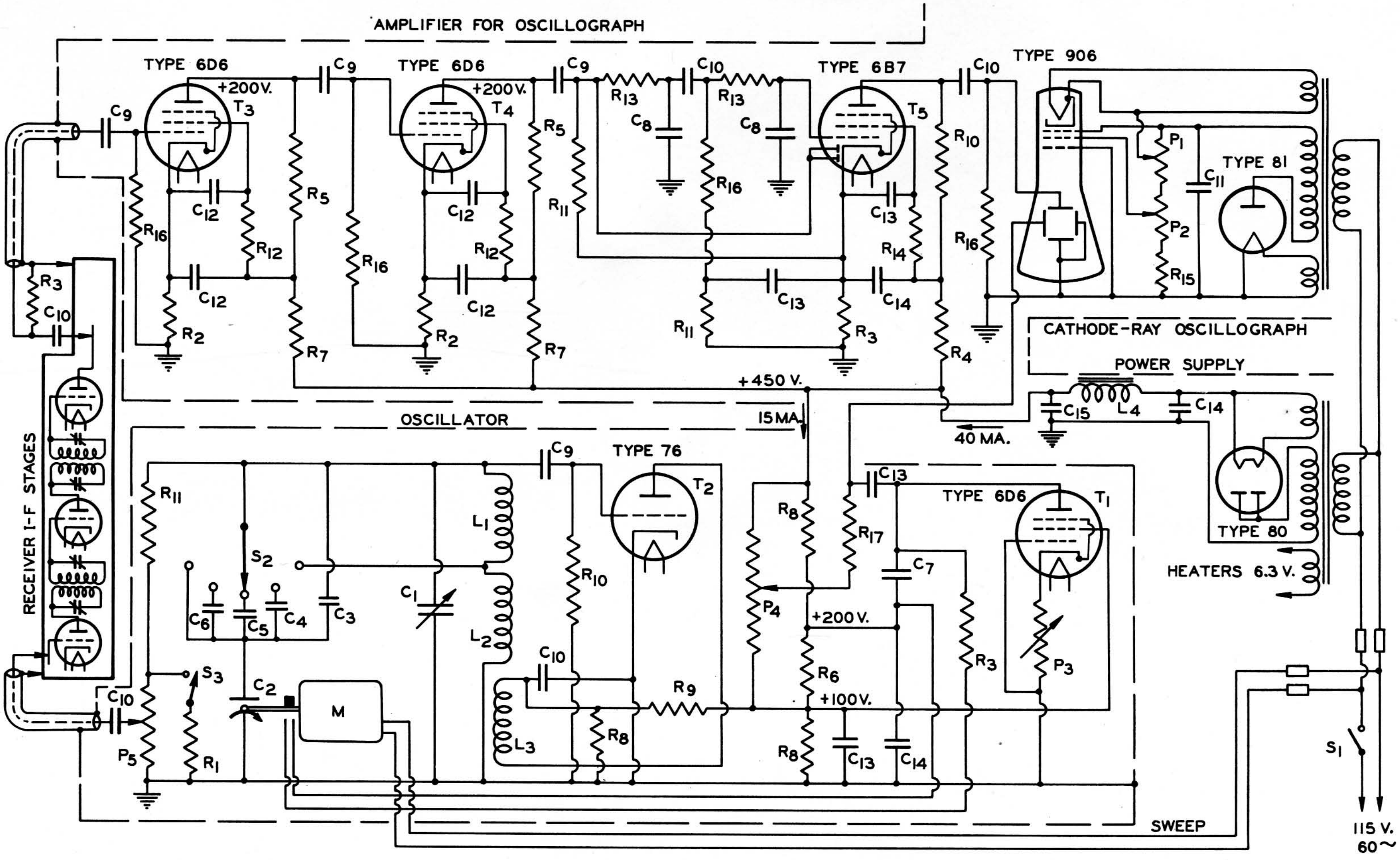

FIG. 1

C_1 = MAIN TUNING CONDENSER
C_2 = FREQUENCY-SWEEP CONDENSER
C_3 =
C_4 = FREQUENCY-RANGE CONDENSERS
C_5 =
C_6 =
C_7 = 0.5 μf
C_8 = .0001 μf
C_9 = .0002 μf
C_{10} = 0.1 μf
C_{11} = 1.0 μf
C_{12} = 2.0 μf
C_{13} = 4.0 μf
C_{14} = 8.0 μf
C_{15} = 16.0 μf
R_1 = 50 OHMS
R_2 = 300 OHMS
R_3 = 1000 OHMS
R_4 = 5000 OHMS
R_5 = 10 000 OHMS
R_6 = 11 000 OHMS
R_7 = 14 000 OHMS
R_8 = 15 000 OHMS
R_9 = 25 000 OHMS
R_{10} = 50 000 OHMS
R_{11} = 100 000 OHMS
R_{12} = 120 000 OHMS
R_{13} = 200 000 OHMS
R_{14} = 300 000 OHMS
R_{15} = 500 000 OHMS
R_{16} = 1 MEGOHM
R_{17} = 5 MEGOHMS
L_4 = 40 HENRIES
M = MOTOR, 1/20 H P - 1800 R.P.M
S_1 = POWER-SUPPLY SWITCH
S_2 = FREQUENCY-RANGE SWITCH
S_3 = TEST-SIGNAL-RANGE SWITCH
P_1 = 50 000 OHMS, BRILLIANCE-CONTROL POTENTIOMETER
P_2 = 200 000 OHMS, FOCUSSING-CONTROL POTENTIOMETER
P_3 = 50 000 OHMS, TIME-SWEEP-CONTROL POTENTIOMETER
P_4 = 200 000 OHMS, CENTERING-CONTROL POTENTIOMETER
P_5 = 400 OHMS, TEST-SIGNAL-CONTROL POTENTIOMETER

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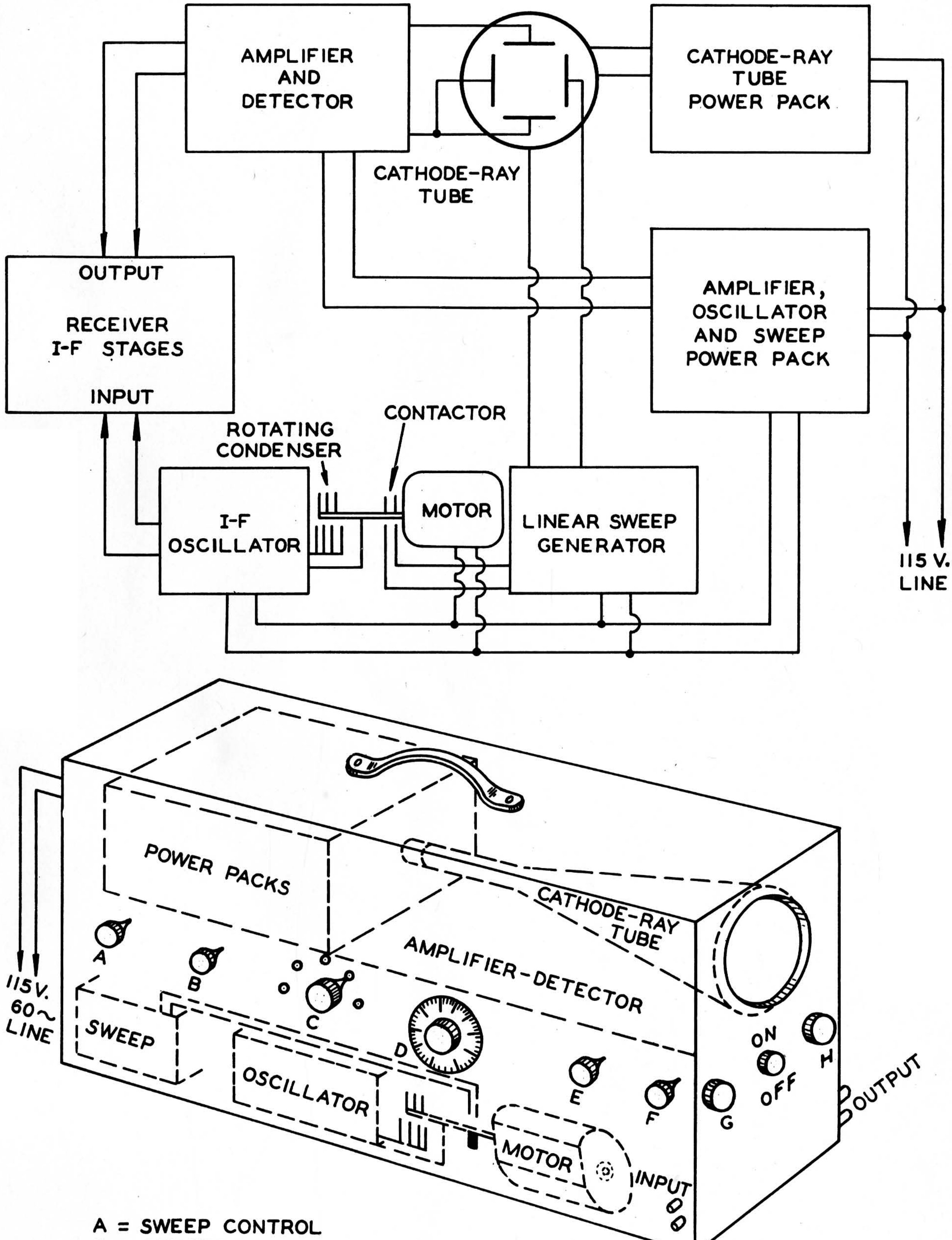

A = SWEEP CONTROL
B = CENTERING CONTROL
C = FREQUENCY-RANGE CONTROL
D = FREQUENCY CONTROL
E = RANGE CONTROL
F = SIGNAL CONTROL
G = FOCUS CONTROL
H = BRILLIANCE CONTROL

FIG. 2

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