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THE SCANNING PROCESS

In the figures on sheet 300.3, S indicates a jet of electrons, which are small particles negatively charged, issuing from the final orifice in the anode A. In traveling down the length of the tube they pass between two of the deflection plates D-D. If the plates are neither negatively charged or positively charged no forces are applied which would divert the jet from its original direction, as in the first sketch. If, however, a voltage is applied to the condenser, one of the plates is given a positive charge and the other a negative charge, relatively, so that the negative charge on each electron is repelled by the negative plate (it is a well known principle in physics that like charges repel) and is attracted toward the positive deflection plate. If the electrons are going rather slowly and the charge on the condenser is high, the ray may be pulled over so far that it actually strikes the positive plate, and is prevented from reaching the screen. This condition is rarely reached and a small deflection only is produced in the direction of the jet while it is still between a pair of plates. The direction of the ray is altered, however, so that it continues on in a new direction. By the time it reaches the screen a much larger deflection may occur.

The mathematical side of this story will not be taken up here. It is sufficient to remember that the actual deflection on the screen is proportional to the following factors:

1. The FIELD due to the deflection plates, which depends upon the applied potential difference, and to their separation. (It is directly proportional to the first factor and inversely proportional to the separation.)

2. The square of the LENGTH OF TIME that the electron is affected by this field. This interval is proportional to the length of the deflection plates, measured in the direction of travel of the rays, and inversely as their speed, since the higher the speed the less time the rays are affected by the diverting field. The effective length of the deflection plates is a little longer than the actual length because of the "edge effect."

3. The MAGNIFYING ACTION of the tube. The ray is deflected a small amount while between the deflection plates. After leaving this field it continues in a new direction until it strikes the walls of the cathode ray tube or the screen. Thus the greater the distance between the plates and the screen the greater the deflection.

After leaving the first set of deflection plates it enters the field of the second pair, placed at right angles to the first. The action here is similar. The ray is given an additional deflection at right angles to that applied by the first pair of plates. This second movement is entirely separate and distinct from the first, and may take place in different degree and at different times. Thus, for instance, while the ray is being moved up and down a few times a second it may be moved back and forth millions of times per second. This extreme independence of action is the factor that permits practical television scanning.

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BALANCED DEFLECTION

The question is frequently raised as to the reason why a balanced deflection system is desirable in television tubes using deflection plates, and even in ordinary oscillographic tubes. In these tubes all deflection plates have separate terminals brought out independently of the anode circuit.

Consider Fig. 1, where deflection plate D1 is connected to the anode. Suppose that 200 volts are applied across the plates with D2 positive. Then the electron ray will be attracted toward D2, but in addition to being deflected it is given an increased velocity by the extra 200 volts on D2. This increased velocity lowers the deflection sensitivity. When D2 is negative, however, the ray is repelled to the D1 plate which is at anode potential. In this location the velocity is unaltered. It will be seen that this change in the deflection sensitivity produces a distorted field, viz., the keystone effect illustrated ~~on sheet~~ in Figure 010.12.

If each plate has a separate lead, however, as in Fig. 2, a center tapped grid leak can be used, with the center tap connected to the anode. In this arrangement the average potential on the plates is zero with respect to the anode, and this type of distortion is substantially eliminated.

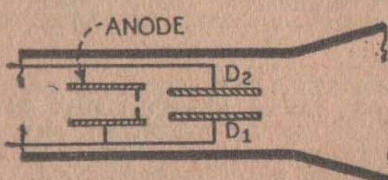

Fig. 1

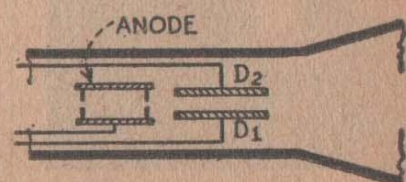

Fig. 2

A push-pull deflection amplifier must be used, however, to maintain this balanced condition after the deflection circuit is connected, or else a transformer with a center-tapped secondary.

A transformer can be easily designed that will pass frequencies up to ten or twenty kilocycles. Such a transformer will pass a saw-tooth wave-form with little distortion up to sweep frequencies of around 2,000 cycles. A tapped secondary will provide the balanced output.

With a step-up ratio, a larger deflection can be obtained, without using amplification.

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SCANNING OSCILLATOR CONTROL

In the television studio the transmitted scenes are dissected into a continuous series of narrow strips which are sent out consecutively. Each transmitter has its own frequency generating equipment which controls the rate of this dissection. It is necessary for each unit of receiving equipment to duplicate these frequencies, not only as to the exact frequency, but also as to wave form and other particulars. This would be very difficult if it were not for the synch ~~interlock~~ pulses which are sent out at the end of each line of the scanned scene, and at the end of each half section of the individual pictures or frames. In the first case the actual frequency of the pulses would be 30x343= 10,290 cycles per second (or 30x441=13,230 cycles per second to conform with the proposed changes in scanning rates.) The picture frequency ~~interlock~~ synch. pulses occur at the rate of 60 per second in either case.

Without these pulses the received picture would weave around at a more or less rapid rate, with the lines crooked or slanting and the results otherwise impossible. The process can be likened to the system of electrical clocks wherein control pulses are sent out from a time observatory to reset the hands at frequent intervals if they are not in the correct position.

Another method has been advocated in some places where the timing pulses are of a nature where they are able to produce the correctly formed and spaced deflection pulses. Here the scanning oscillators are replaced by scanning amplifiers. However, the present tendency is to use the former system.

In future sections, devoted to the technical details of television construction, these pulses will have to be considered in two places: the receiver must be designed so that they are amplified sufficiently, and without phase alteration. Then some sort of a filter must be installed to separate the pulses from the rest of the matter for application to the respective deflection oscillator. In addition, the latter oscillators (commonly referred to as sweep circuits) must be arranged to accept these pulses as the controlling factor in their operation. If the scanning oscillators have a frequency of operation of their own that is adjusted fairly accurately to that at which they must operate, the problem of ~~interlocking~~ synchronization is simplified.

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SCANNING WAVE CHARACTERISTICS

The fundamental purpose of a scanning oscillator is to produce the potentials necessary to bring about the transverse movements of the spot across the screen. To keep the spot moving it is necessary that the potential applied to the deflection plates be continually varying, and the variations must be in every way equivalent to the scanning potentials used with the transmitting studio camera. It is not feasible at the present stage of developments to have the transmitting station do more than set the rate at which these voltages recur by providing synchronizing pulses. It is then up to the receiver designer to provide scanning oscillators that produce the other characteristics of the scanning potentials, such as ~~linearity, amplitude, &c.~~ correct waveshape, amplitude etc.

At some future time it may be found that it is economical to have master transmitting stations send out scanning waves, which are universally applicable to the reception of any transmitted program. Special receiving sets attuned to these waves would produce the required scanning deflections without local oscillators. There are several problems which must be considered before such a plan is feasible, such as possible time lags between the studio transmitter and the pulse transmitter which would tend to cut the scene in two sections.

The easiest kind of a scanning potential to produce locally is a true sine wave, requiring the simplest type of oscillator. However, the spot does not move at a constant speed, slowing down as it approaches or leaves the edges of the scenes. At those edges, where actually the picture brilliance and detail need not be as great, more time is spent than at the center where greatest clarity is needed. (See page 300.1).

For this reason, at least for television plans in this country, a saw-toothed wave is utilized for scanning in both directions. The spot moves at a constant rate in one direction and returns to the starting point at an extremely rapid rate, so fast indeed that the return of the spot is indistinguishable. The development of such a wave form will be taken up on following pages. During the return trip the spot is extinguished however.

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SCANNING WAVE CHARACTERISTICS

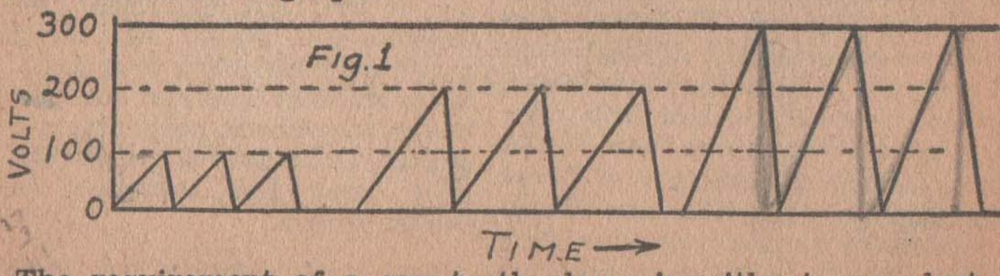
As outlined on sheet 300.8, the television scanning spot (in both horizontal and vertical movements) must move across the screen at a constant rate and return very quickly. So far, the time allowed for the return sweep movement has not yet been standardized. Engineers are waiting to determine this time from circuit considerations. This return interval, of course, is wasted time and should be as short as possible. For the purposes of analysis it may be considered as comprising 5 per cent of the total time. It may be greater than this for the line frequency wave and much smaller for the picture frequency.

Figured back in terms of voltage, a constant speed of the spot movement means that a potential applied to the deflection plates is increasing at a constant rate. A quick return means that this potential drops to the initial value rapidly. The maximum value of the required potential wave depends upon the deflection sensitivity of the cathode ray tube, and this in turn upon the anode potential applied to it.

For example, it takes the following voltages applied to the deflection plates of a type 54-8-H tube (DuMont) to produce a deflection three inches long:

Anode voltage on tube.........	1000	2000	3000
Deflection voltages............	110	220	330

Thus spot brilliance, which is obtained by increasing the anode voltage, is obtained only at the cost of a more expensive scanning equipment, since it is more difficult to obtain a deflection voltage amplitude of 500 volts than one of 200 volts. Fig. 1 represents a picture of this wave from the above three representative voltage requirements. A picture of this type is known as an oscillogram and is of the kind that can be produced by a cathode ray tube connected as an oscillograph.



The requirement of a saw-tooth shape is without precedent in electrical engineering, and a different technic must be applied in the design of oscillators for its production, than for any other commercial frequency.

Sheet 300.9.

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THE SCANNING OSCILLATOR

In general the scanning process is based on a slow potential build-up in a condenser, or a current build-up in a coil, with a discharge at frequent and definite intervals. The principle may be illustrated by the following diagrams, which compare the charging ability of a condenser with the storaging capacity of a tank for water.

An empty tank connected by a pipe to a full tank will fill almost instantly after the valve is opened, if the connecting pipe is short and very large in diameter. In the same way a condenser connected to a source of potential, such as a battery, will charge quickly, if the resistance in the wiring is kept small. If the connecting pipe is long and its diameter small, the water will merely trickle through and some time may elapse before the ultimate level is reached. The same occurs in the condenser arrangement if the resistance in the charging leads is large. These conditions are shown in Figs. 1 and 2. In other words the voltage across the condenser will build up gradually, which gives us a start toward getting the required scanning wave characteristics for deflection of the spot.

In Fig. 2, however, as the water rises in tank B, the head of water in that tank produces an ever increasing back pressure which tends to slow down the rate at which water passes through the pipe. The tank starts to fill up rapidly, but when nearly full the level increases much slower. Here again the analogy represents the exact condition found in the condenser circuit, and the curve, Fig. 3, represents the water (or voltage) level at different intervals of time. The charging curve is therefore *not linear*. Means must be provided for straightening out this curve before it is useful for the purpose at hand.

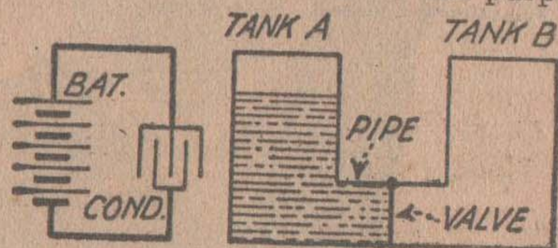

FIG. 1.

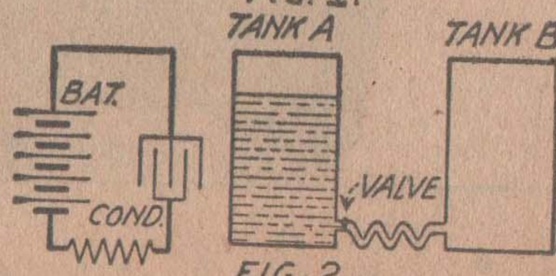

FIG. 2.

Sheet 300.10

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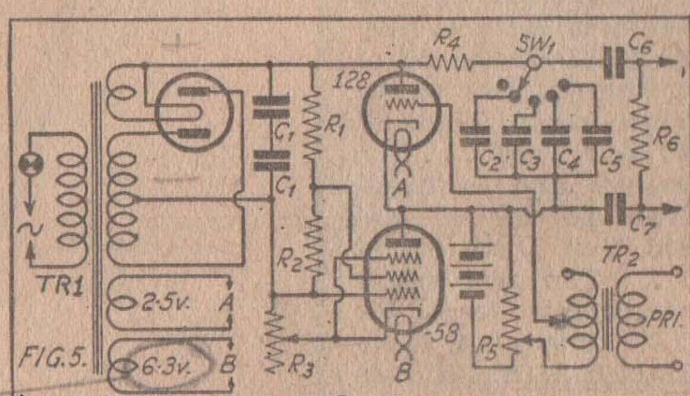
THE SCANNING OSCILLATOR

(Continued from Sheet 300.12)

The skeleton circuit shown in Fig. 4 is reproduced in Fig. 5 with all symbols replaced by actual circuit elements. This circuit can be assembled into a useful oscillographic time base or "linear sweep," as it is sometimes called. For television purposes, however, certain additions are necessary which will be described later, since the output potential (height of the saw-tooth wave as shown in Fig. 1, page 300.9) is hardly great enough to produce scanning on tubes larger than 3 inches in diameter.

The charging voltage is ~~now~~ obtained from a power unit connected to ~~supply obtained from~~ the usual line supply a. c. voltage. Since this portion of the circuit is not unlike the usual transformer-rectifier-filter circuit it need not be described further here, since the principle is the same. ~~The next change is the replacement of the current limiting resistance shown in Fig. 4 by a vacuum tube, in this case a type 58.~~

2.5



SUGGESTED PARTS FOR OSCILLOGRAPH TIME BASE

TR1—Thordarson T7540.
TR2—Thordarson T8101.
C1—Aerovox type PBS5 (8-8 mfd.)
C2—.1 mfd. type 1084.
C3—.02 mfd., type 1084.
C4—.004 mfd., type 1084.
C5—.001 mfd., type 1084.
C6, C7—.5 mfd., types 684.
R1—150,000 ohms, 1 watt.
R2—50,000 ohms, 1 watt.
R3—25,000 ohm potentiometer, Ex-Stat.
R4—1,000 ohms, 1 watt.
R5—5,000 ohm potentiometer, Ex-Stat.
R6—3 megohms, 1 watt.
Sw—Five point switch.
128—Type 128 gas filled triode (DuMont)

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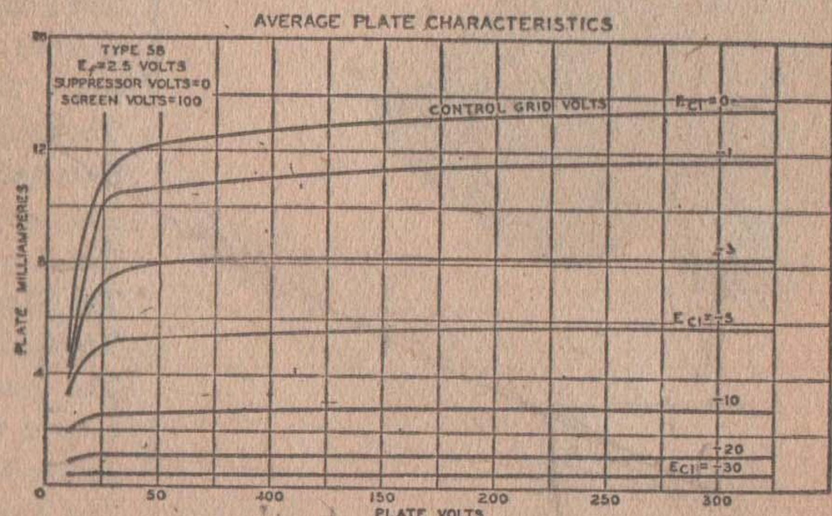
THE SCANNING OSCILLATOR

The reason for the substitution of a pentode for the current limiting resistance in Fig. 4 may not be apparent to many. Therefore reference may be made to Fig. 6 which shows the plate characteristic curves of this tube. The feature of immediate interest here is that the plate current is largely independent of the plate voltage. The plate current is dependent on the bias voltages applied to both the control grid and the screen grid in this tube, and not upon the plate voltage, since the plate current is nearly constant for all plate potentials over 50 volts.



is evident

In other words it seems that the plate resistance increases about as rapidly as the plate voltage so that the ratio of E/R (based on Ohm's Law) is substantially constant. As explained on Sheet 300.11 one of the best methods of making the charging curve of the condenser linear with respect to time is to charge the condenser with a constant current.

In order to set the charging rate at the desired value to produce the required frequency the negative bias applied to the control grid is altered from zero to about minus 50 volts, a range that permits quite a wide range of frequencies. As a means of further increasing the output frequency range several values of capacity are provided any one of which may be inserted by the operation of the selector switch Sw. Thus both control dials associated with resistance R3 and the Sw are labeled "Frequency."

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THE SCANNING OSCILLATOR

(Note—In Fig. 5, sheet 300.13, the type 7540 transformer has two 2.5 volt windings, instead of the 2.5 and 6.3 volt windings shown.)

In the circuit, Fig. 5, the function of the transformer TR2 is to permit the synchronization of the oscillator frequency with some standard frequency or else one that is directly related to the phenomena under investigation. Usually the timing base frequency so produced must be exactly adjusted to a definite value, but this type of oscillator does not remain stabilized very well. Therefore it must be interlocked with the circuit under test whereby pulses from the latter are introduced directly into the grid circuit of the discharge tube. These pulses can therefore be introduced into the primary winding of this transformer.

For best results the oscillator must be adjusted so its natural frequency is approximately equal to the frequency of the interlocking pulses (or a multiple of this frequency). In television the scanning oscillators are set at 60 and 13,230 cycles, with present standards (sheet 300.7), so that pulses of these frequencies filtered out of the incoming signals, are applied to the interlock circuits of the scanning oscillators.

The function of the control R5 in this circuit is to control the bias applied to the discharge tube. The potential is obtained from the battery (for the type 128 tube a 4.5 volt C battery is sufficient). The higher the negative bias applied to this tube the higher the voltage amplitude of the deflection potentials. R5 is therefore of the nature of an amplitude control and its setting determines just how large the diagram will appear on the screen, of the cathode ray tube. This control also affects the frequency at which the time base operates, but this effect is secondary. After any change in the setting of R5 it may be necessary to readjust R3 to restore the frequency to the original value.

The function of the resistor R4 in this circuit is to prevent the too rapid discharge of the condenser. If the current surge during the discharge interval is excessive, the tube may be damaged, and the resulting surges induced in other associated apparatus may cause unwanted interference. If this resistance is too large the discharge is slowed down too much and the flyback time is lengthened needlessly.

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THE THYRATRON

Gas discharge tubes, or thyratrons, have been frequently referred to in these pages. In scanning oscillator applications, the outstanding advantages of this type of tube are: The low impedance of its anode circuit (after discharge has started) and the extremely high impedance during the interval that no discharge is taking place. Their high speed of operation permits their use at any scanning frequency found in television practice.

They resemble in many ways the usual three-element vacuum tube, with the exception that they are filled with mercury vapor or other inactive gases. The main advantage possessed by the mercury type of thyratron is the ability to handle relatively large discharge currents. On the other hand when the cathode heating current is first turned on considerable time elapses before the mercury pressure becomes stabilized enough to operate satisfactorily. In addition the operating characteristics depend largely upon the ambient temperature inside the bulb. For example, a setting which permits the breakdown to occur at 1,000 volts at a temperature of 25° Centigrade, might break down at 600 volts if the temperature was increased to 40° Centigrade. In this case to re-establish the original break-down condition it would be necessary to increase the negative bias by about a third.

While the inert gas type of thyratron (which may be filled with argon, neon, &c.) has more reliable operating characteristics, still, the carrying capacity (of types available for television) is too low to take care of the discharge of condenser charges to more than 350 volts. The type 885 discharge tube falls in this class.

For this reason when larger deflection potentials are needed, it is necessary either to amplify the lower voltage pulses, or to use the mercury type tubes, relying on the interlocking pulses to keep the frequency constant. In a later section such methods will be described in detail. Amplified scanning oscillators are commonly used in both British and German television receivers.

The grid in a thyratron functions differently from that in an ordinary triode. It controls the potential at which the discharge occurs and once this discharge takes place, the grid is no longer effective and cannot stop the plate current. The latter can be stopped only by removing the potential. Since in scanning oscillators the plate potential is obtained from a charged condenser, the discharge stops as soon as the charge has been dissipated.

Sheet 300.16.

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BIAS CONTROL FOR THYRATRON TUBES

To control properly the aspect ratio of the television picture (or the horizontal length of an oscillogram) the discharge of the thyratron must be controlled. This has been shown to be dependent upon the negative bias applied to its grid circuit. In many cases a small C battery is used to supply this potential, but it is possible to obtain the required voltage from the circuit itself.

Usually the charging condenser is connected across the plate and cathode of the thyratron, to prevent the discharge current from affecting the bias in this tube. This current flows only during the discharge interval and may reach a value of many hundred milliamperes in some cases, and cause high bias potentials to build up.

It is quite possible, however, to make use of this current by the connections shown in Fig. 1 wherein the voltage drop across the bias resistor Rx is used to charge up a rather large by-pass condenser Cx, which will store up enough energy during the discharge interval to last for the charging cycle. The action is not simple, however, since this condenser has its greatest charge immediately after the discharge occurs. This condition has some advantages since the tendency is to de-ionize the thyratron more rapidly. Between charges, the condenser Cx steadily loses its charge and the result is that the bias voltage drops during that interval until it is of the right value to start the discharge at the right time.

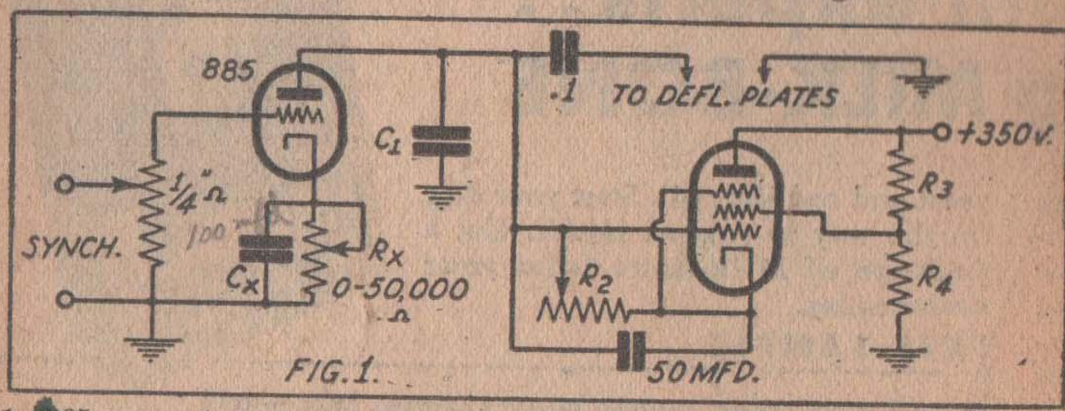

FIG. 1.

R1 0.25 meg., 1 watt.
R2 0-0.5 meg., Exstat.
R3 0-0.25 meg., Exstat.
R4 0-0.5 meg., Exstat.
R5 100,000 ohms, 2 watts
R6 30,000 ohms.
R7 10,000 ohms.
R8 1,000 ohms.
R9 50,000 ohms, 1 watt.
R10 350 ohms, 1 watt.
R11 2 meg., 1 watt.
C1 (See fig. 2).
C2 0.1 mfd., type 484 Aerovox.
C3 25 mfd., type PB50 Aerovox.

(Values are for Fig 300.18

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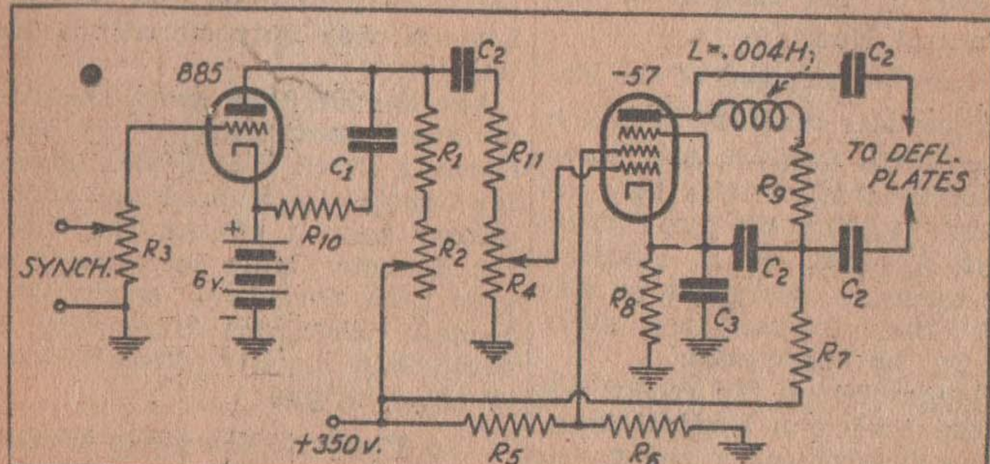
SCANNING OSCILLATOR CIRCUITS

If deflection voltages greater than a couple of hundred volts (peak) are needed to produce the required deflection for scanning, it will be necessary to charge the condenser in the timing circuit (C2 to C5 in the circuit on page 300.13) to rather high voltages. This will necessitate the dissipation of large currents in the thyratron during the discharge interval. Some designers therefore prefer to generate low potential sawtoothed waves and then to amplify them in the usual manner. If the amplifier used is properly designed, linearity can be obtained either way, and it happens that about the same amount of equipment is required with either system. A less expensive thyratron tube can be used in the amplified system, however.

A comparison between the systems will be made. It is found that the usual 3-inch cathode ray tube (such as the DuMont 34-X-H or the R. C. A. type 906) requires about 225 volts applied to the deflection plates to get a 2.5-inch swing, when the tube is operated at 1,200 volts anode. A sweep circuit will be figured out that will give about a saw-tooth wave peak of about 50 volts and an amplifier will be used to increase this peak to the 225 volts. Such a circuit is shown in Fig. 1. A control grid bias of 6 volts must be applied to an 885 thyratron tube to get it to break down at a 50-volt level.



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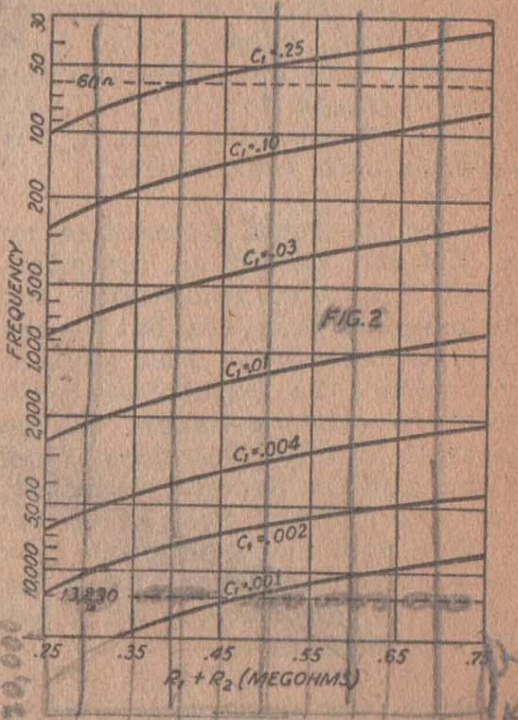
SCANNING OSCILLATOR CIRCUITS

Since the scanning frequencies are known (60 and 13,230 cycles) the circuit values in the charging circuit can be at once computed. Since some readers may wish to use the sweep at other values for oscillographic purposes, the required capacities for intermediate frequencies have also been plotted in Fig. 2. These curves give at once the required timing capacity. They are based on the usual exponential charging curve for a condenser and are arranged for the condition where the charging resistance (R1 and R2 in Fig. 1) is adjustable within the limits of 0.25 and 0.75 megohm.

The amplifier tube used here is a type 57 although any tube having similar characteristics may be substituted. The inductance L in the plate circuit of this tube will hardly be necessary except for the 13,230 cycle scanning frequency and can be omitted for lower scanning rates. Its use insures that the amplifier frequency range is extended so as to cover the upper harmonics of the 13,230 cycle fundamental to insure sufficient linearity of the output wave.

In this circuit a six-volt C battery is permanently connected in the grid circuit of the thyratron. This is one of the easiest ways to secure a proper bias for a 50-volt discharge rate. Minor changes in the deflection amplitude are obtainable by adjustment of the input pontentiometer of the amplifier tube. Other methods of securing this bias have been discussed on page 300.17, which may be substituted if desired.



Provision is made for the application of synchronizing pulses into the thyratron control circuit. This matter will be discussed in detail on another sheet for the case of television synchronization. For oscillographic work, however, any suitable interlocking pulses can be applied to the synchronization terminals to steady the sweep frequency.

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SCANNING OSCILLATOR CIRCUITS.

The curves shown on sheet 300.19 indicating values of R and C for typical time base circuits described on sheet 300.18 are based on the condition that the condenser C1 is charged up to a voltage equal to one-seventh of the maximum voltage of the circuit at the time that each discharge occurs. In other words with a 350 volt supply the discharge is set to 50 volts if the curves are to hold accurately. For a 1,000 volt supply the discharge must be set to a value of 143 volts. Under this condition the charging curve is substantially linear even without the constant current limiting tube in the charging circuit.

The same curves can be used at other discharge levels as well, if a correction factor is applied, as follows: shown in the curve Fig X

Ratio $\frac{E_{MAX}}{E_{BREAKDOWN}}$	10	9	8	7	6	5	4
Correction Factor	1.47	1.32	1.16	1.00	0.85	0.70	0.52

If the values of both R and C remain unchanged, the frequency resulting is that shown on the curve, sheet 300.19, multiplied by the above factor. Or if either the charging resistance or the condenser C1 is increased in value according to this correction factor, the frequency will remain unchanged.

It is not recommended that the breakdown potential in such circuits be much greater than about one-seventh of the maximum voltage, if good linearity is to be maintained. In all of these circuits it is necessary to provide condensers with adequate breakdown safety factor to withstand momentary high voltages during the intervals when the breakdown condition in the thyratron is abnormal, such as when the tube is heating up.

The amplified scanning oscillator circuit (300.18) will produce scanning potentials sufficient for the usual 3″ or 5″ cathode ray tube operated at 1,000 to 1,500 volt potentials. In such tubes one plate of each pair of deflection plates is connected internally to the anode.

(Note—The circuit constants for sheet 300.18 were inadvertently published at the bottom of sheet 300.17.)

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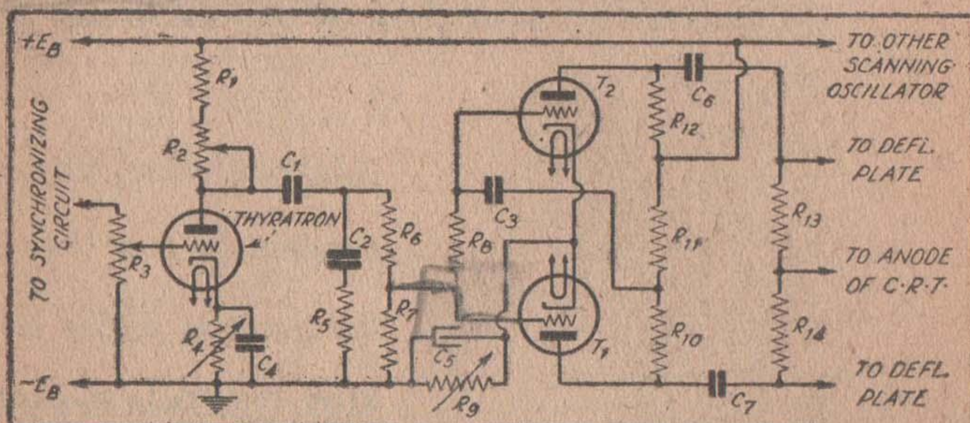
PUSH-PULL SCANNING CIRCUITS FOR LARGE TUBES

The circuit shown below is particularly adapted for tubes which have all deflection plates isolated from the anode. It is not greatly different from the circuit shown on sheet 300.18 except that a push-pull amplifier stage is used. In order to produce linear amplification with large voltage swings it is necessary to use an unusually high anode potential on this stage. However since such a voltage is available, some economy results here since the saw-tooth wave oscillator operating at high potentials will give a linear sweep without resorting to the constant-current charging tube, described on sheet 300.14.



Circuits of this type are common in television reception, especially in the commercial receivers used in Great Britain and Germany. An investigation has shown that the main differences to be found in the scanning oscillator circuits of these receivers is in the means used to couple the push-pull stage of the saw-tooth oscillator. The circuit shown here has been tried out by the author, using the constants given. Layout and constructional details will be given later together with certain operational features that have been found advantageous.

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PUSH-PULL SCANNING CIRCUITS FOR LARGE TUBES

(Continued.)

In this circuit it will be seen that the potential drop across one-half of the frequency controlling condenser is used, that is, the latter is made up of two condensers in series. It will be seen that this saw-toothed wave is further reduced by the resistors R6 and R7 across the grid of the amplifier. If we assume that Eb is 1,000 volts, and that the thyratron is adjusted to break down at 148 volts, the curves on sheet 300.19 will hold. Fig 14 may be used.

The grid of the amplifier tube T1 is thus supplied with an 18-volt swing. If the voltage gain in the push-pull stage is 14, the output will be approximately 250 volts to the deflection plates. If a greater deflection is needed the input resistances R6 and R7 can be altered to provide a greater input swing, or the charging potential can be made greater than 1,000 volts.

Only one deflection amplifier is shown, since the alternate scanning potential can be obtained from the duplicate of this circuit, with the exception of a change in the condensers C1 and C2 as shown in the following list of parts. One power supply will suffice for both. Connections to the synchronizing terminal are described elsewhere.

The following table applies to the schematic diagram on sheet 300.21:

R1 0.50 megohm (1 watt).
R2 0 to 1.0 megohm (Exstat)
R3 0 to 0.5 megohm (Exstat)
R4 0 to 50,000 ohms (Exstat)
R5 1,000 ohms (1 watt).
R6 1.5 megohms (1 watt).
R7 0.5 megohms (1 watt).
R8 2.0 megohms (1 watt).
R9 5,000 ohms (2 watts).
R10 85,000 ohms (2 watts).
R11 15,000 ohms (1 watt).
R12 0.1 megohm (2 watts).
R13 and R14 each 2 megohms.

C1 and C2 each 0.25 mfd. type 684 Aerovox.
(C1 and C2 each 0.001 mfd. type 1084 Aerovox).
C3 0.1 mfd. type 1084 Aerovox.
C4 and C5 each 50.0 mfd. 25 volts.
C6 and C7 each 0.1 mfd. type 1084 Aerovox.
T1 and T2 triodes, such as —56 or equivalent.

Note—The second value of C1 and C2 is for a 13,230 cycle scanning oscillator. All other values hold for both 60 cycle and 13,230 cycle oscillators.

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Omit

PHASE INVERSION

The push-pull stage of the scanning oscillator shown on sheet 300.21 utilizes a type of phase inversion, so that both of the amplifier tubes function correctly, by having their input potentials substantially 180° out of phase. If the tube T1 has a gain of 7, the two resistances R10 and R11 are proportioned so that the voltage drop across R11 is one-seventh of the drop across both R10 and R11. The amplified signal from T1 is reduced in this ratio and is thus applied to the grid of tube T2 The latter grid is thus 180° out of phase with the input to T1.

The voltages appearing at the output of these tubes are applied to the appropriate deflection plates through coupling condensers C6 and C7. Since these plates are not connected to the anode of the electron gun, it is necessary to introduce two leak resistances, R13 and R14, across the plates and to connect the center point between them to the anode of the cathode ray tube.

For correct amplification the voltage reduction across the R10—R11 combination must be equal to the voltage gain produced by the tube T1. In the usual case therefore it will be necessary to introduce a variable resistance in the circuit for R11 in order to make accurate adjustments. When the correct value is found it can then be replaced by an equivalent fixed resistance. R9 is adjusted so that the anode current in each tube is approximately that called for when the tubes are operated at their normal plate voltages, instead of the higher values used here.

In an alternate circuit it is possible to make the resistance R8 a variable potentiometer and to connect the grid of T2 to the slider. The input condenser C3 is connected between the upper end of this potentiometer and the anode of T1. In this case the resistances R10 and R11 can be replaced by a single resistance of 0.1 megohm. In either case the results are the same and the adjustments are made in a similar way. The only difference being that in the first case the voltage reduction takes place in the anode circuit of T1 and in the alternate scheme, the division is made in the grid circuit of the second tube (which is often referred to as the "slave" tube).

If both the line and frame scanning oscillators are mounted on the same base it is advisable to run a shield between them to prevent inter-coupling and to mount all the parts symmetrical. The filaments of all the tubes are supplied with rated voltages from the main power supply.

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MAGNETIC DEFLECTION COIL SCANNING

Since large cathode ray tubes are more difficult to assemble and exhaust, it is desirable to eliminate the deflection plates from within the tube since this reduces the cost of the renewable portion of the receiver (and hence the upkeep) by lowering the cost of the tube, at the expense of somewhat more elaborate scanning oscillator arrangements. In some cases it has been found economical also to eliminate the focusing electrodes in large tubes, and to effect focusing by means of large external magnetic fields.

Large tubes require high anode potentials to secure adequate light and it is found that the deflection voltage which must be applied to the internal deflection plates is directly proportional to the anode potential used. However with magnetic deflection coils the deflection sensitivity is inversely proportional to the square root of the anode voltage.

Stated in figures, a magnetic deflection oscillator circuit must be twice as powerful if the anode potential is increased from one kilovolt to four kilovolts, whereas if deflection plates were to be used the deflection voltage would have to be four times as great (an actual power comparison would be difficult to make for these cases).

It seems logical, therefore, that magnetic deflection circuits will become extensively used when large cathode ray tubes are common items in television receivers. In this service the frequency at which a particular set of deflection coils is to be used is defnitely known so that the magnetic circuit can be accurately laid out. Where a large frequency range is desirable, as in oscillographic, work it may be necessary to use air-core deflection coils, but in television work it is possible to use iron-cores with an attendant increase in the efficiency. Deflection increases of the order of ten to one are easily possible with iron core coils, although it is more difficult to design the various factors in the circuit so that linearity results.

It is also necessary that the finest grade of lamination material be used so that the retentivity of the field is small. If the laminations retained any portion of the applied field, a permanent shift of the axes of the scene would take place and other distortional effects would take place.

Deflection coils are current operated devices so that a current amplifier stage must be used in conjunction, where a large change in the current takes place in accordance with the scanning frequencies. In other words a power stage is needed.

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MAGNETIC DEFLECTION COIL SCANNING (Cont.)

At the present time most of the commercial television receivers sold by European manufacturers use a magnetic ally deflected system. Direct current saturation is avoided by condensers of suitable size in series with each pair of coils.

It is necessary that the turns in the sections of each pair be balanced so that stray fields are reduced to a minimum. Such fields from an unbalanced coil would penetrate the turns of the other pair of coils and produce a deflection component in a direction at right angles to the desired direction.

The time constant of the coils is altered by the presence of the series condenser but they are designed so that substantial linearity is maintained at both the line and framing frequencies. Resonance conditions are frequently encountered in the line frequency deflection coil circuit, however, which would entirely destroy any linearity, so that it is a common expedient to use less turns on the line scanning deflection coils. Even then there is considerable energy which must be dissipated during the discharge interval. This energy is sometimes disposed of by shunting the coil with a one-way absorbing device, which dissipates the energy in the coil whenever the polarity is that occuring during the discharge interval.

One such circuit, recommended by the RCA in conjunction with circuits developed for the type 1800 and 1801 cathode ray tubes, consists of a half wave diode (an ordinary rectifier tube) in series with an absorbing circuit—a resistance and capacity in parallel. The diode is connected so that it is conductive for the discharge current which has a polarity opposite to that which flows through the circuit while it is producing the deflection.

The time allotted for the discharge to take place is 10 per cent of the scanning time in each direction (10 per cent of 1-13,230 second is approx. 7 microseconds as stated above) but it is desirable that an even faster discharge be provided if possible to insure that all transients will have died out before the next line starts. Then again, the discharge may not occur immediately after this time interval starts, due to the delay possible before the synchronizing pulse takes hold and triggers off the discharge.

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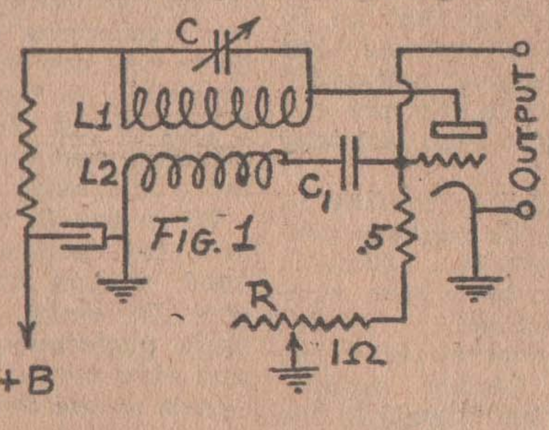
MAGNETIC DEFLECTION COIL SCANNING
(continued)

For a number of years a scanning circuit has been used in Great Britain and credited to Appleton, Herd and Watt, which has an ordinary triode oscillator as its essential element. It differs, however, from an ordinary oscillator in the matter of the grid bias. In order to oscillate efficiently a definite grid bias potential must be applied to the tube, which may be obtained from a fixed voltage, or by the rectified grid potential. If a condenser is inserted in the grid circuit of the tube, the radio frequency currents in that circuit will be rectified by the grid-cathode circuit of the tube, and a charge will appear across the condenser C1. In fact, if no provision is made to enable this charge to leak off the voltage will reach such a high value that the tube will stop oscillating. If, however, a grid leak is placed in the circuit the charge will ultimately leak off and the tube will start oscillating again. If a leakage current is great enough, the charge will leak off as fast as it accumulates on the condenser and the grid voltage does not reach a value high enough to stop the oscillations. This is the arrangement which is used in an ordinary r-f oscillator circuit. For scanning oscillator circuit, however, a higher value of grid leak resistance (R) is used, as in Fig. 1.



Oscillations start up, charge the condenser and stop. As soon as the charge leaks off the action is repeated. The voltage across the grid condenser therefore has a waveform somewhat similar to the saw-toothed type. The discharge curve can be made linear by using a constant current discharge tube instead of the leak (R), such as was described in 300.14. There is no definite relation between the oscillator frequency and the sweep frequency except that the former is much higher. In one arrangement tested a 455 KC oscillator was used, where L_1 and L_2 were made from a standard i f transf

SHEET 300.26.

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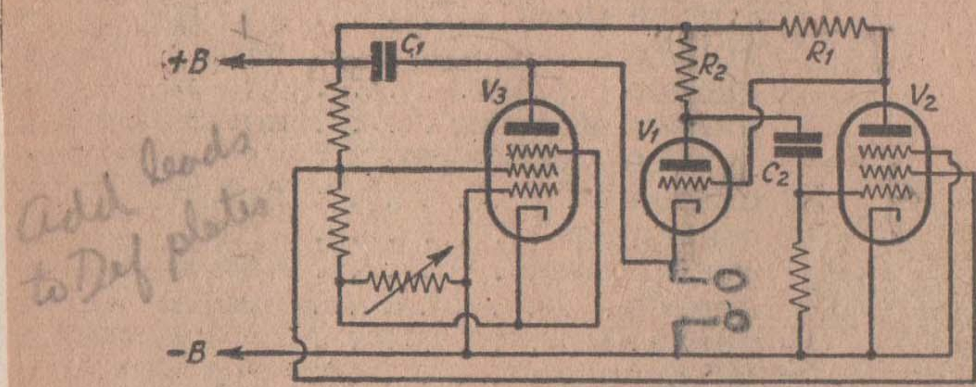
SCANNING OSCILLATORS USING HARD TUBES

Due to the vagaries of a gas-filled discharge tube, such as a thyratron which are due to changes in the temperature of the bulb, A great many advantages are to be found in scanning oscillator circuits that use high vacuum tubes, such as are found in ordinary receivers.

A circuit of this type is shown in the accompanying diagram, which was developed by the English firm of Cossor Tubes, Ltd. In the circuit the condenser C1 functions as the usual timing condenser and is charged at a constant rate through the pentode V3 so that the potential of the charge increases at a linear rate. During the interval that the condenser is charging, V1 is biased below cut-off.



This bias for the tube V1 is due to the current drop in the resistance R1 in the plate circuit of the pentode V2. As it charges up ultimately, the voltage across C1 reaches a value high enough to alter the bias to V1 so that it is no longer below cut-off, and plate current starts through V1. This causes a potential drop across R2 which rapidly increases in value. The voltage increment across R2 is thereupon applied to the grid of V2 through the condenser C2. This second tube now functions to reduce the current in R1 and thereby reduces the bias to the grid of V1. As the bias decreases rapidly the anode current increases rapidly from this point. It will be seen that the action is regenerative so that almost instantly the tube V1 has a positive bias and an extremely low plate resistance. This permits the condenser C1 to discharge rapidly through the tube V1. This tube therefore replaces the thyratron of the usual circuit.

At the end of the discharge the current in R2 ceases and the initial non-conductive state of affairs is re-established.

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SCANNING OSCILLATORS USING HARD TUBES (continued)

this
In ~~the~~ circuit ~~(300.27)~~ the moment-to-moment voltage across the condenser C1 is applied to the deflection plates of the cathode ray tube, either directly or through an amplifier.

Several methods have been used for applying the synchronizing pulses to this circuit. In one arrangement the screen grid of the tube V2 is modulated by the synchronizing pulses. The pulses must have a polarity such that the plate current of V2 is decreased, so as to lower the voltage drop across R.

Another method is to modulate the control grid of V2, which acts in the same way.

In any method it is desirable to apply the synchronizing pulses through a single stage amplifier, to prevent the surges from the scanning oscillator from passing out into the various circuits where they are not wanted. Surges will not pass backward through such an amplifier stage into the wrong circuits.

In using this circuit with magnetic deflection coils, best results are obtained when a two stage amplifier is used. A "buffer" stage (which can be a simple triode amplifier) is capacitively coupled to the charging condenser C1, which in turn drives a power stage. The latter should have a low impedance output tube, such as 2A3.

Inasmuch as there is always some distortion in amplifier tubes due to curvature in the operating range of the characteristic curve, this curvature, if correctly applied, can be used to counteract curvature due to non-linearity in the scanning wave if any is present. Methods for accomplishing this will be taken up in later sheets.

In the practical setup of this circuit, best results will be obtained when V1 is a high-mu triode, V2 a pentode without remote cutoff, and V3 a pentode with remote cutoff ~~(a super-control type)~~. The values of the resistance R2 can be determined by experiment for the particular triode used, and will ordinarily be one or two thousand ohms. R1 will have a higher resistance—from 0.1 to 0.5 megohm, depending upon the amplitude of the sweep desired. If made variable it can be used for amplitude control.

SHEET 300.28.