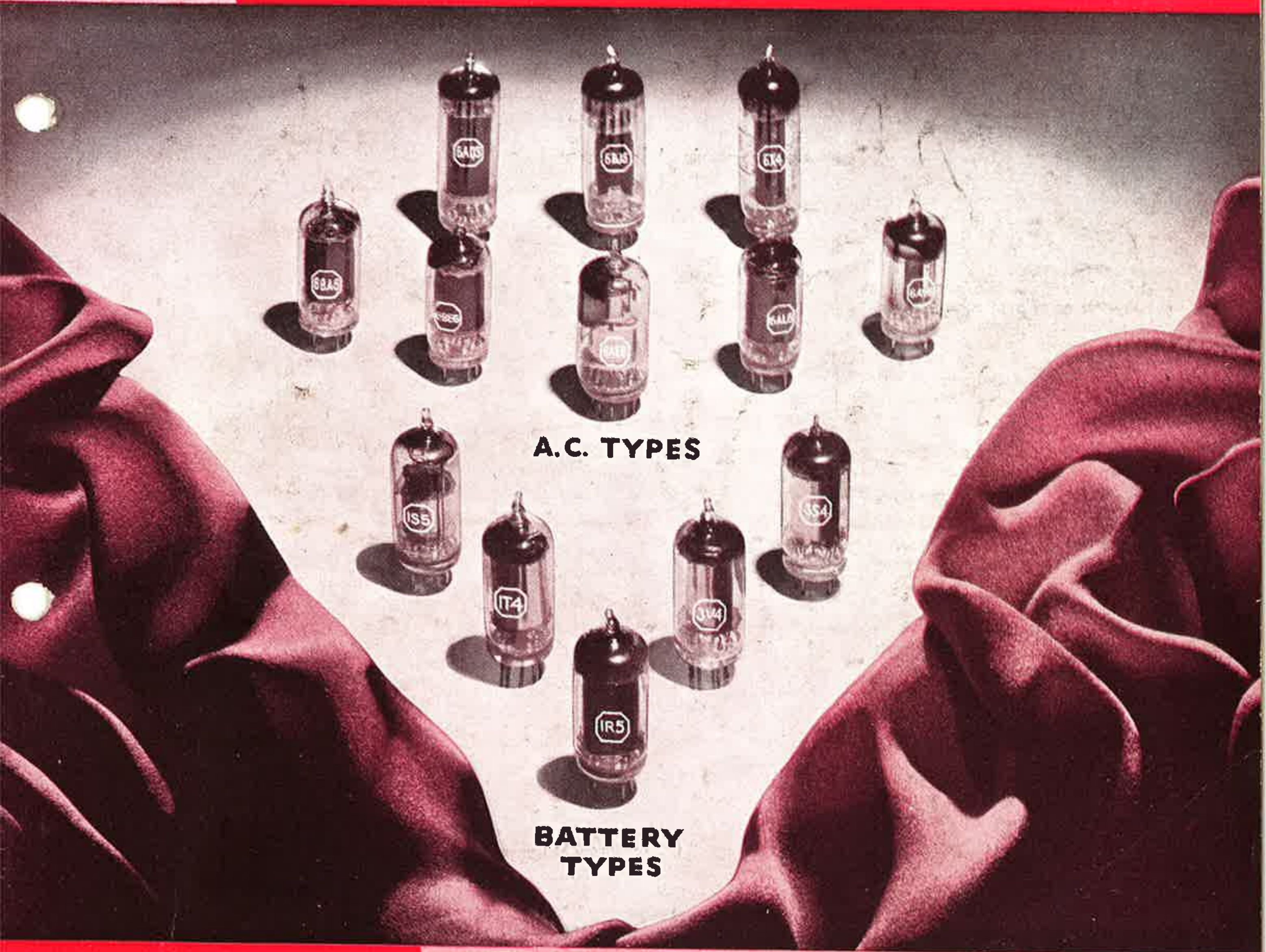
RADIOTRONICS

Vol.16 February 1951 No.2



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RADIOTRONICS

Volume 16 **February, 1951** **Number 2**

By the way—

We have much pleasure in announcing the appointment of Mr. R. Lambie as Manager of the Amalgamated Wireless Valve Company with his office at 47 York Street.

Prior to this, Mr. Lambie held the position of Works Manager of the A.W. Valve factory at Ashfield.

The new 1951 Radiotron Valve Data Book, for which a record number of advance orders have been received, is expected to go to press early in March. We regret that production of this manual has been delayed owing to power restrictions. Copies of this up-to-the-minute reference manual should be in the mail at the end of the same month.

Featured on our front cover is a selection of miniature valves taken from the AWV 1951 Radiotron range.

Subscribers are asked to check their address as stencilled on the Radiotronics envelope and advise us immediately if found incorrect. Changes of address should also be advised promptly.

Should a subscriber fail to receive an issue for any reason, this should be brought to our notice as soon as possible. Due to the limited printing of each issue, supplies of back numbers cannot be guaranteed more than a few months after publication.

With this issue is included a list of Radiotrons featured in the 1951 range of recommended receiving valves. The attention of manufacturers and other users of valves in new equipment is drawn to this list which indicates modern types likely to be readily available this year.

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A Panoramic Adaptor with a *Circular* Time Base

By **W. E. Babcock** *

Simultaneous visual reception of a large number of radio signals over a broad band of frequencies is provided by the panoramic adaptor. It may be used with almost any type of receiver and provides an indication of the frequency, type, and strength of all signals within a given bandwidth (centred at the frequency to which the receiver is tuned). When used to spot unoccupied channels in the band it can be an invaluable aid in avoiding interference problems. When used with a calibrated scale it becomes an accurate frequency meter. The amateur who owns a panoramic adaptor will no doubt find many additional uses for it.

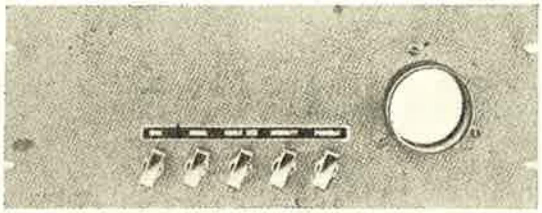

Figure 1. Panel view of the circular base line panadaptor showing position of the front controls and CR tube face.

Basically, a panoramic adaptor is a superheterodyne receiver with a broadly tuned r-f stage and a narrow-band i-f stage. However, in the conventional superheterodyne receiver, the local oscillator is fixed in frequency at any one time, while in the panoramic adaptor, the local-oscillator is frequency modulated over a given band. In commercial panoramic adaptors, all signals within the bandwidth covered by the r-f stage are shown on a cathode-ray tube as vertical "pips" on a horizontal base line. In the panoramic adaptor described here (and shown in Figure 1), a circular base line is used on which signals appear as radial pips extending toward the centre of the screen. The frequency of any signal appearing as a pip on the screen is determined by the position of the pip on the circumference of the circle as shown in Figure 2. The centre frequency (to which the companion receiver is tuned) is shown at zero, while other signals are shown in proper frequency relationship to this zero.

General circuit description

A circuit diagram of the panoramic adaptor is given in Figure 5. The signal input to the adaptor is taken from the plate of the converter tube in the receiver. The 6AU6 r-f stage is tuned to the intermediate frequency of the receiver and has a rising frequency characteristic either side of the centre frequency to compensate for the drooping frequency characteristic resulting from the selectivity of the r-f stage in the receiver. The plate circuit of the 6BE6 mixer stage is tuned to 160 k.c., while the oscillator section is varied over a range of 50 k.c. above and below 616 k.c. (456 k.c., the usual receiver i-f, + 160 k.c.) at a rate of 60 times per second. The sawtooth voltage driving the reactance modulator tube, and the circular sweep voltage for the cathode-ray tube are both derived from the 60-cycle line voltage.

Plate and screen voltages for all tubes except the cathode-ray tube are obtained from a conventional

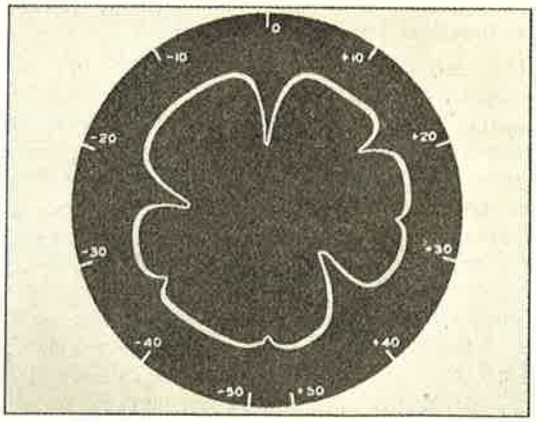

Figure 2. The position of the pips on the circumference of the circle indicates the frequency of the received signals.

***Application Engineering, RCA Tube Dept., Harrison, N. J.**

Reprinted from Ham Tips, by courtesy of Radio Corporation of America.

full-wave rectifier. The screen voltage for the reactance modulator tube is held constant at 150 volts by the OA2 voltage regulator tube. The anode voltage for the cathode-ray tube is obtained from a voltage-doubler circuit in which the output voltage is added to that from the full-wave rectifier to give a total second-anode voltage of approximately 1100 volts. *This high voltage is dangerous.* Extreme care must be exercised if it is necessary to work on the adaptor with the power on. Be sure the high voltage filter capacitors are discharged when making tests with the power off.

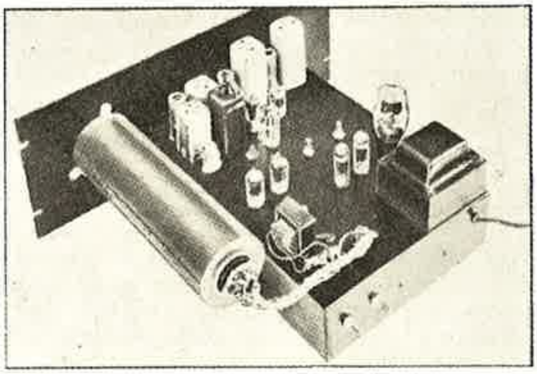

Figure 3. A bird's eye view of the panadaptor illustrates the chassis layout. The cylindrical sleeve supports the c-r tube.

Use of standard components

All components used in the construction of the panoramic adaptor are standard receiver replacement components. Many hams will no doubt have many of the parts on hand. The transformers used in the i-f stages are designed to tune to 175 k.c. However, their tuning range is such that they may easily be tuned to 160 k.c. Maximum width of the pips obtained when these transformers are used is approximately 5 k.c. at the base line. This bandwidth is sharp enough for observing signals differing by less than 5 k.c.

Construction and layout details

The adaptor is constructed on a 10″ × 14″ × 3″ chassis with a standard 7″ × 19″ × ⅛″ rack mounting panel. Figures 3 and 4 illustrate the chassis layout. No special precautions are required in constructing the adaptor other than those normally practised in constructing receiver i-f stages. The cathode-ray tube, of course, should be mounted as far from the power transformer as possible to minimize hum pickup on the deflection plates. If difficulty is experienced with hum pickup on the grid of the cathode-ray tube, it may be necessary to add a 4 μF capacitor (C_{32}) from the cathode of the 3KP1 to the arm of the intensity control.

Auxiliary use

For the station that does not have a modulation monitor, the cathode-ray tube in the panoramic adaptor can be used for this purpose. For this use, capacitors C_{28}, C_{29}, C_{30}, and C_{31} should be connected by means of a 4-pole double-throw relay so they will connect the deflection plates of the cathode-ray tube to the plates of the deflection amplifier tubes in the adaptor on "receive" and to the r-f and modulating voltages of the transmitter on "transmit". The coupling to the transmitter should be such that the voltage ratings of C_{28}, C_{29}, C_{30}, and C_{31} are not exceeded.

Alignment procedure

Variable resistor R_{35} and capacitor C_{26} form a phase-shifting network which applies two sinusoidal voltages 90° out of phase to the push-pull grids of the deflection amplifiers. R_{35} should be varied until the best circle is obtained. A separate 6.3-volt filament transformer is used to supply the voltage to the phase-shifting network. It would be possible to supply this voltage from the filament winding of the power transformer, except that any heater-cathode leakage in the tubes would result in spikes being superimposed on the heater voltage and consequent distortion of the circle. If the line voltage has a perfect sinusoidal wave form, the circle on the screen of the cathode-ray tube will be very nearly perfect. Although in most cases, the line voltage will vary slightly from a perfect sine wave, the resulting pattern will still be very nearly a circle.

During alignment of the i-f stage, a high-impedance d.c. voltmeter is connected across the detector load resistance (R_{14}). With R_{22} set at zero, a 160 k.c. signal from a signal generator is applied to the signal grid (grid No. 3) of the 6BE6 and the i-f transformers are peaked for maximum d.c. voltage across the detector load resistance.

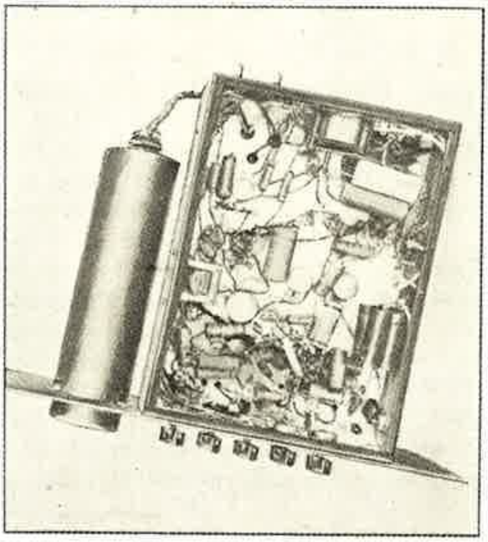

Figure 4. Placement of components and wiring on the under-chassis of the panadaptor reveals compactness without crowding.

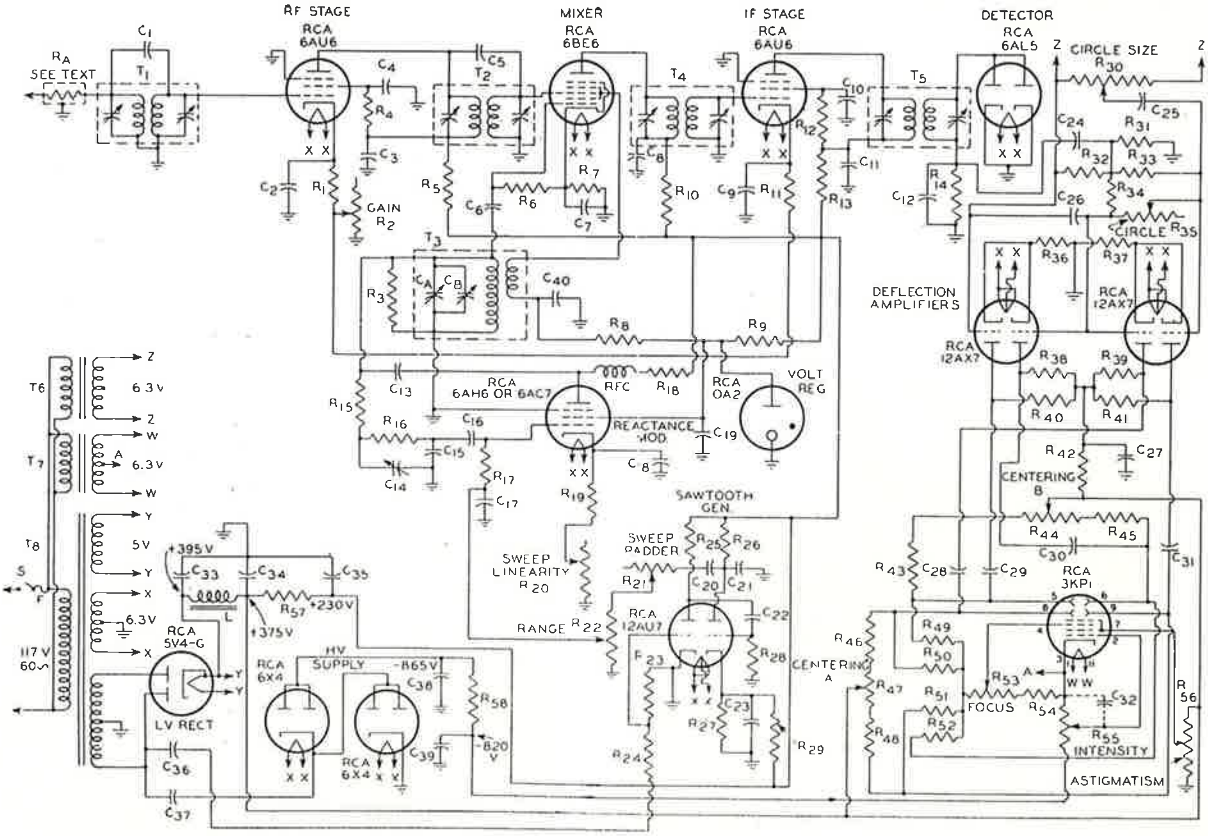

Figure 5 Schematic of the panadaptor

Figure 5. Schematic of the panadaptor.

PARTS LIST

C1, C5	47-uuf ceramic
C2, C3, C7, C8, C10, C11, C28, C29, C30, C31, C40	0.01-uf 400 V paper
C4, C9, C18, C25	0.1-uf 400 V paper
C6	68-uuf ceramic
C12, C13	470-uuf mica
C14	1—10-uuf ceramic trimmer
C15	15-uuf mica
C16	100-uuf 600 V paper
C17	270-uuf mica
C19	0.006-uf 400 V paper
C20	0.25-uf 400 V paper
C21, C22, C27, C36, C37	0.1-uf 600 V paper
C23	25-uf 25 WV electrolytic
C24	0.03-uf 400 V paper
C26	1-uf 600 V paper
C32	4-uf 150 WV electrolytic
C33, C34	16-uf 450 WV electrolytic
C35	40-uf 450 WV electrolytic
C38, C39	0.1-uf 2000 V paper
RA	47,000 ohms, in receiver connected to plate of converter tube
R1	100 ohms
R2	10,000 ohm potentiometer—linear taper
R3	51,000 ohms
R4, R12	22,000 ohms
R5, R10	4700 ohms 1 watt
R6	24,000 ohms
R7	150 ohms
R8	6800 ohms
R9	2200 ohms 5 watt
R11, R19	100 ohms
R13	3300 ohms 1 watt
R14	680,000 ohms
R15	20,000 ohms
R16	100,000 ohms
R17, R31, R32, R33, R34, R58	220,000 ohms
R18	3000 ohms 1 watt
R20	500,000 ohm potentiometer—linear taper
R21, R44, R47, R56	1 megohm potentiometer—linear taper
R22	100,000 ohm potentiometer—linear taper
R23, R24, R25, R26, R28, R54	1 megohm
R27	4700 ohms
R29	51,000 ohms 2 watt
R30	20 ohm potentiometer, 5 watt
R35	5000 ohm potentiometer—linear
R36	270 ohms
R37	390 ohms
R38, R39, R40, R41	27,000 ohms
R42	3300 ohms
R43, R45, R46, R48	3.9 megohms
R49, R50, R51, R52	20 megohms
R53	2 megohm potentiometer—linear taper
R55	0.5 megohm potentiometer—logarithmic taper
R57	2500 ohms, 10-watt
T1	456-kc i f transformer;
T2	456-kc i f transformer;
T3	Oscillator transformer;
T4	175-kc i f transformer;
T5	175-kc i f transformer;
T6, T7	Filament transformer 6.3 volts, 1 amp;
T8	Power transformer 350-0-350 volts 120 ma;—6.3 volts, 4.7 amp; 5 volts 3 amp;
S	SPST switch (mounted on R55)
F	Fuse
RFC	RF choke 30 mh
L	Filter choke—8 henrys—150 ma

All resistors 0.5 watt unless otherwise specified

Variable capacitor C_{14} controls both the magnitude and phase of the r-f voltage appearing at the control grid of the reactance tube. Its setting is not critical, but during the adjustments described in the following paragraph, it should be set near maximum capacitance. If it is desired to increase the frequency range of the adaptor, at a sacrifice of linearity, approximately 50 k.c. more deviation may be obtained by setting C_{14} to minimum capacitance.

Sweep padder, R_{21} is used to set the amplitude of the sawtooth voltage obtained from the plate of the sawtooth generator so that the total frequency deviation of the local oscillator is exactly 100 k.c. when R_{22} is at maximum. It should initially be set at about half scale. The centre frequency f_0 should be set to the proper value (616 k.c. if the companion receiver has an i-f of 456 k.c.). Capacitors C_A and C_B which are contained in oscillator transformer T_3 are used to set f_0. C_A is a coarse tuning adjustment which may be turned with a screwdriver; C_B is a fine tuning adjustment controlled by a knob at the top of T_3. However, R_{20} in the cathode circuit of the reactance tube will also have a slight effect on f_0. R_{20} is used to set the cathode bias of the reactance tube so that the frequency deviation of the oscillator is linear. It should be set initially to give a cathode-to-ground voltage of approximately 2 volts. With control R_{22} set at minimum and with a 456 k.c. signal applied to the signal grid of the mixer stage, C_B is then adjusted to give maximum d.c. voltage across R_{14}. Control R_{22} is then set at maximum. A pip, corresponding to the 456 k.c. input signal, will now appear on the screen of the cathode-ray tube. The tube may be rotated so that this pip appears at the top of the screen. The signal generator frequency should now be shifted 50 k.c. above and below the centre frequency of 456 k.c. The pip will be seen to rotate around the circle as the frequency is shifted. When the deviation of the local oscillator is set to exactly ± 50 k.c., the pip will travel almost the full 360° of the circle as the signal-generator frequency is shifted from 406 to 506 k.c. If the pip moves around the circle before the range is covered, the sawtooth voltage applied to the grid of the reactance tube is not great enough and the resistance of sweep padder R_{21} should be decreased until the proper frequency range is covered. If too great a range is covered, the resistance of R_{21} should be increased.

Linearity and bandwidth

Approximately 10° at the bottom of the circle is taken up by the retrace of the sawtooth voltage driving the reactance tube. During this interval, the local oscillator is being frequency-modulated 50 k.c. each side of f_0 in the same manner as during the rising portion of the sawtooth, except that the deviation is in the opposite direction and occurs in a much shorter time. This deviation causes a small pip to appear at the bottom of the circle whenever a signal is applied to the adaptor. Since this pip occupies such a small portion of the circle (approximately 10°), it will appear to remain stationary as the input signal frequency is varied. It may be used as a dividing marker between 406 and 506 k.c.

After the frequency deviation of the local oscillator is set to the proper value, the linearity of the deviation should be checked. If the deviation is linear, half the circle will be traced for a 50 k.c. frequency change of the signal generator. If either more or less than half the circle is traced, R_{20} should be adjusted slightly. Since any adjustment of R_{20} causes a slight shift in f_0, the setting of C_B must be changed to correct it. If the linearity is poorer, the adjustment of R_{20} has been in the wrong direction. After R_{20} is set for best linearity, it may be found that the frequency range covered has changed and R_{21} will have to be adjusted also.

Capacitors C_1 and C_5 are used to overcouple the r-f transformers and thus give a rising frequency characteristic each side of the centre frequency (456 k.c. for most receivers). The primaries of T_1 and T_2 are tuned approximately 10 k.c. below the maximum frequency to be received (496 k.c.). The secondaries of T_1 and T_2 are tuned approximately 10 k.c. above the lowest frequency to be received (416 k.c.). Approximate alignment is obtained by applying a 496 k.c. signal from a signal generator to the input of the adaptor and adjusting the primaries of T_1 and T_2 for maximum deflection on the screen of the cathode-ray tube. The signal-generator frequency is then changed to 416 k.c. and the secondaries of T_1 and T_2 adjusted for maximum deflection.

Final alignment

The final alignment should be done with the adaptor connected to the plate of the converter tube in the receiver with which it will be used by means of a 47,000-ohm isolating resistor (R_A). This resistor should be connected as close to the converter plate as possible and a shielded lead used between the resistor and the adaptor input. With the receiver tuned to approximately 3 Mc, set the signal generator to the same frequency and tune the receiver until the signal appears as a deflection at the top of the screen. Then change the signal generator frequency 50 k.c. higher, moving the deflection clockwise to the bottom of the screen. Adjust the trimmers on T_1 and T_2 until the amplitude of the deflection is approximately the same as it was at the centre. Then change the signal generator frequency 50 k.c. lower, moving the deflection counterclockwise to the bottom of the screen. Again adjust the trimmers to make the amplitude of the deflection approximately what it was at the centre. This second adjustment will upset the first adjustment, and it will be necessary to go back and forth and to compromise on adjustments in order to make the gain as nearly uniform as possible over the entire 100 k.c. range.

Alignment for other frequencies

The r-f stage of the adaptor may be aligned for centre frequencies from about 420-500 k.c. If the companion receiver has an intermediate frequency

(Continued on page 40)

TELEVISION ECONOMICS

By J. Rhys-Jones

There are two mutually opposite routes which television receiver development can follow:

The first is the "way of the scientist." It will be agreed that the true scientist is an idealist to whom television is a wonderful field in which to continue his search for perfection. He does not hesitate to push up number of lines, bandwidths, and receiver circuit complexity in his efforts to improve picture quality. The resulting receiving equipment and system which it accepts will be excellent, but will not create a large viewing following, as it will be forced into the higher price bracket.

At the other extreme lies the even more dangerous road—commercialism, which brings in its train such evils as price war, unsound equipment, inferior performance, and unstable operation.

Somewhere between these opposing trends lies the true ideal, and the purport of these remarks is to suggest certain features which may be worthy of inclusion in this "ideal".

The immediate ambition of the television industry of the various interested countries should be to attract the biggest possible percentage of the population as interested participants in television and to maintain that interest. This formula spells stability and success. The achievement of this ambition demands the following:

1. Economical first cost.
2. Economy in maintenance.
3. Economy in operating cost.
4. Ease of operation.
5. Stability of adjustment.
6. Satisfactory picture quality.

It will be of interest to take these items, in the order given, and analyse them more fully.

Economical first cost is achieved by adopting simplicity in design in the mechanical layout, in the circuitry, in the overall conception of the complete apparatus, and in the design of the various component parts.

Economy in maintenance is achieved by incorporating the minimum number of those pieceparts which rank as consumable items, owing to the fact that they have a definite expectation of average life, at the end of which replacement should be anticipated. This requirement is also aided by a careful selection of all components and valves to ensure that each is the best value in its class, considered on the balance of first cost against life. On this score, it is generally advantageous to remove as many valves from the circuit as possible, particularly those which are likely to have a relatively short life, even if it means adding to the number of long life components already incorporated.

Economy in operating cost is automatically achieved by the adoption of economy principles of design, some versions of which are discussed here.

Ease of operation and stability of adjustment are dependent on good engineering combined with adequate experience, and a wise choice of the various components.

Satisfactory picture quality is influenced largely by the definition presented, and on this feature it has been established by H. L. Kirke and others that the best picture detail is obtained when the vertical definition is equal to the horizontal definition. This fact is independent of the effective bandwidth transmitted through the whole system. The explanation for this reasoning is quite logical. A shortening of the viewing distance to take advantage of improvement in definition resulting from any increase in bandwidth transmitted through the system, will result in the line structure becoming visible.

This factor should be considered, in parallel with the well-known fact that the wider the pass band of an amplifier, the more noise it admits, and incidentally the more complex it becomes, when considering extending the range a transmitter is expected to cover. It is recognised that the bigger the expected range, the smaller should be the bandwidth, to reduce noise on picture, but as just explained, a reduction in number of lines should also follow to make the best use of this reduced bandwidth.

Acceptance of this fact implies that simultaneous coverage of the short range and long range annular rings of viewers is not possible without some sacrifice from the optimum for some ranges. The compromise has proved satisfactory to date, but viewing ranges are being extended and larger numbers of lines are being considered. It is well to ensure that all these aspects are given due consideration. It may be that a plea can be made for a lower definition system, of the order of 200 lines, transmitted on as low a frequency as possible for long range working.

Halving the number of lines, whether for interlaced or sequential scanning, would divide the bandwidth by four, and the retention of interlacing, with its smaller bandwidth demand, would permit a balanced picture transmission with a bandwidth of about half a megacycle.

Pursuing this thought it is possible to envisage a television receiver with a two-position switch, one position designated "high definition" and the other position designated "international".

Interlacing is of advantage, in that it reduces the

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required bandwidth, but it is disadvantageous in that it gives a stroboscopic effect on vertical movement, and in addition the line structure rapidly becomes obvious with but a small departure from accuracy of interlace.

Some experiments carried out with a receiver experimentally fitted with a continuously operating control permitting variations in accuracy of interlacing, indicated that few commercial receivers, as operated by the owners, have a sufficiently precise interlace to give the vertical definition possible. In addition, such a control is essential on an experimental receiver to allow an evaluation of the picture quality possible with perfect interlace. Accuracy of interlace is controlled entirely by the synchronising circuits and the deflection circuits. It can be momentarily disturbed by incoming interference.

General presentation

The psychological satisfaction of a television programme is aided by operating the loudspeaker at the correct level of output, which it will be found is a function of picture size. It should be realised that the main appeal of television is to the sight, and that the hearing is a secondary effect which is complementary to the vision. If the sound stimulation is permitted to swamp the visual stimulation by operating the loudspeaker at excessive volume, the overall psychological satisfaction is reduced.

Recognition of this fact pays good dividends as it permits the incorporation in the receiving equipment of a smaller audio power output stage, and a smaller loudspeaker. The use of a smaller power output stage reduces the high tension current needed, which in turn reduces the size of the high tension smoothing equipment, and may also allow the fitting of a smaller high tension rectifying valve. The use of a smaller loudspeaker may permit a reduced cabinet size and so on. It will thus be seen that these gains are cumulative and all of these gains aid economy.

The television industry in England is actively engaged in exploring the avenues which will increase the availability of the television broadcasts. Several excellent models have already made their bow, and prices are reaching figures which are within the means of large sections of the public. A number of representative models have been analysed and the following figures obtained which indicate certain trends:

Total number of valves considered adequate to-day varies between 14 and 21.

Number of fixed resistors required by a modern television receiver varies between 49 and 84.

Number of capacitors of all types required in a modern television receiver varies between 30 and 63.

Number of r-f coils considered necessary in a modern television receiver varies between approximately 10 and 20.

Number of adjustments fitted has a bottom figure of 7 and a top figure of 10.

Cost per pound weight varies between $16\frac{1}{2}$ shillings and $25\frac{1}{4}$ shillings. Cu. ins. of volume per shilling cost varies 3.1 cu. ins. and 6.7 cu. ins.

These figures have been obtained from information published in recent articles in The Wireless World.

Antennas can provide considerable assistance to any television receiver, and in most instances receiver economies can be realised by utilising these possibilities. The antenna can do much more than just pick up some sort of voltage from the ether to hand on to the receiver input. Its ideal function is to impress the maximum possible voltage across its feeder for the field strength available and to provide that voltage with the highest possible signal-noise-ratio.

Where the installation is being operated in a region having a high field strength, there is not the need to make such efforts to realise high signal-noise ratio figures, as the noise voltage will generally be swamped for this class of usage, and two main forms of antenna become possible.

The first is of normal construction, having a useful gain, and therefore making a relatively insensitive receiver possible. In the interests of economy it will only be used in its directional form in areas of strong interference.

The other utilises some form of self-contained or indoor antenna, several forms of which are possible. This last method has two useful attributes. The receiver when fitted with such an antenna, providing it is a reasonably compact model of adequately low weight, becomes a portable model, which can be easily moved from room to room or place to place. This feature is a real advantage in operation. In addition the cost and bother of installing an antenna together with its associated feeder is obviated, which, apart from the obvious increase in usefulness, makes demonstration by a dealer to prospective customers considerably simpler.

For use in districts suffering from a lower field strength, the opening remarks of this paragraph regarding good signal-noise ratios and large gains become applicable. An antenna for this class of service generally requires height and space for results, and these are not always available. Where they are, however, maximum use should be made of them, as the requirement from the receiver is thereby reduced, and the operating range of a given receiver is increased. It should be borne in mind that vertical directivity is as important as azimuthal directivity in all except areas of high field strength, particularly if the antenna can be installed at a reasonable height, as ignition and other man-made interference is thereby reduced together with aircraft flutter.

Aircraft flutter can be reduced, except in the bad cases which are usually created by large aircraft flying at low altitudes, by adding automatic gain control to the receiver, but the results are much improved by the use of vertically directive antennas.

Much is to be gained by giving some care to the design of the part of the receiver which comes before the input grid of the first valve. This includes the aerial system itself, the transmission line cable, and the input transformer to the receiver. The impedance of the aerial, as seen at the point of connection, should equal the impedance of the transmission line connected to that point, and the transformer inserted between the other end of the transmission line cable and the input grid of the receiver should be so designed that it terminates the transmission line cable with its own impedance. If these requirements are fulfilled, a maximum voltage will be applied to the receiver, and the system will be free from multiple images or ghosts caused by discontinuities in the transmission line.

Power supplies

Power supplies for the valve heaters and for the high tension current circuits can be obtained in several ways. The valve heaters can be connected in parallel and operated from a step down transformer. Or they can be connected in series, in which case they can still be operated from a transformer, which may be double wound or which may be auto connected, or they can be connected directly across the supply mains, a series of resistance being added if necessary.

The high tension current for the anode and screen circuits can be obtained from either a double wound or an auto connected transformer, via either a full wave or a half-wave rectifying valve. If a half-wave rectifying valve is used in conjunction with an auto-connected transformer, the transformer may be used as a voltage step-up device, and this arrangement presents an economical power supply circuit, as the use of auto-connection, together with the avoidance of the need for the transformer to supply the valve heater power, results in a transformer of small volume.

It is possible, however, to satisfactorily operate a television receiver from a high tension voltage no higher than can be obtained from the direct rectification of the 230-volt mains, and the use of this technique removes the need for any transformer whatever. Apart from the saving of the cost of the transformer itself, there is a further saving. It is known that a transformer, when operating, has a stray magnetic field which distorts a cathode ray tube scan, and this distortion has to be obviated, or at least minimised in a television receiver by careful positioning and orientation of the transformer.

This requirement is sometimes disturbing to a layout, as it generally adds to the overall dimensions of the apparatus, and certainly adds to the weight. All this is avoided if the use of a transformer can be obviated.

A further advantage of this transformerless form of operation lies in its ability to operate directly from direct current supply mains.

A modification of the transformerless scheme just detailed uses one of the series type heater full-wave rectifying valves which are now available, in a cascade type of voltage doubling circuit. This modification excludes the facility of operation from direct current supply mains, but does make available a considerably higher value of high tension voltage.

Probably the biggest problem in the design of a television receiver is the circuit of and components incorporated in the line or horizontal deflection portion of the time base. This is particularly the case when there is incorporated the high voltage generating circuits for the anode supply to the cathode ray tube, which is, of course, modern practice.

It is customary to generate this high voltage by suitably stepping up the voltage which appears at the anode of the scanning current generating valve during the flyback portion of the sawtooth, and rectifying it with a half-wave rectifier. The usual arrangement of this portion of the circuit involves the use of a transformer which couples the cathode ray tube line or horizontal scanning coils to the anode circuit of the scanning current generating valves. A continuation of the primary winding steps up the flyback voltage for supply to the anode of the cathode ray tubes and an additional winding on the transformer heats the filament of the valve which rectifies this voltage.

Certain problems have to be overcome in the design of this transformer. The main one is that, due to the transient nature of its operation, magnetostriction causes it to emit a troublesome note at its operating frequency. This can be minimised by wrapping the impregnated transformer in a sponge rubber case, and positioning this in a heavy metal case. This treatment adds to cost and, in addition, permits a temperature rise during operation, which because the transformer is totally enclosed, can bring about further troubles.

Pressed block cores having characteristics in some ways better than those exhibited by laminated sheet metal cores, have been introduced both in England and America, and it is found that their magnetostrictive effect is so low that it is unnecessary to enclose them in any sound reducing structure.

Using this type of core reduces the number of piece parts associated with the transformer, facilitates assembly in that it obviates the stacking of the laminations, reduces the chassis area needed for mounting, and permits adequate ventilation of the component in operation. In addition, the absence of the normal metal screening case permits a lower distributed capacity across the transformer winding, which eases design or improves performance, as the case may be.

The use of these moulded block cores for line scanning transformers becomes of bigger advantage with increase in line repetition frequency, owing to the higher "*Q*" value possible for a given permeability. In addition the reduction in distributed capacity following the ability of dispensing with a screening can become more useful as the line frequency is increased.

Regulation of the high voltage applied to the cathode ray tube anode should be good, to avoid defocusing of the picture in the highlights. A typical regulation figure which can be obtained with a transformer of the type just mentioned, is quoted here for reference purposes as experience indicates that it is entirely adequate.

For a cathode ray tube cathode current change from zero microamperes to 300 microamperes, the high voltage change is from 7,800 volts to 7,400 volts. (The cathode ray tube used to obtain this figure was of triode type fitted with a metal-backed screen, and 300 microamperes approached full white.) This regulation agrees with the generally accepted figure which states that taken over a range in level from black to white a voltage regulation figure of 5 per cent. is good, and approaching 10 per cent. is just about acceptable.

Scanning generators

Generation of the saw-tooth scanning current required for line or horizontal deflection is most frequently carried out by the utilisation of a saw-tooth voltage generator, which may be either a soft or a hard valve, followed by an amplifier of adequate capacity to provide the requisite volt amperes for deflection.

When operating the receiver from a low value of high tension voltage, as is the case with transformerless supply, it is generally deemed necessary to incorporate an efficiency diode, to recover the otherwise wasted magnetic energy. This means that three valves are required, together with other attendant expenses, such as valve holders, various associated components, extra soldering operations in assembly, etc.

There is a slowly growing cult towards making the amplifying valve self-oscillating and thus saving the saw-tooth voltage generator. When this is done it is found that the grid circuit of this valve acts as its own efficiency diode, thus obviating the need for a separate valve to provide this function. This arrangement approaches the utmost that can be realised at the present stage of the art in this portion of the circuit, as it requires but one valve to provide the line or horizontal scanning current for deflection, and to generate the high voltage for the cathode ray tube anode supply.

Providing that the circuit operates at the correct frequency a change in the high tension voltage applied to the valve, does not cause an appreciable alteration in picture size, as the scanning power varies sympathetically with the extra high tension voltage being generated for the cathode ray tube anode, which gives a balanced operation for any reasonable changes.

This line deflection part of the receiver has many conflicting features in its requirements, and the best design generally becomes the best assembly of compromises. The various components can be fabricated, each having the highest efficiency possible, and each contributing the minimum of distortion, such as non-linearity and defocusing. The circuit can be laid out in the same ambitious manner. This practice will not, however, produce the competitive receiver.

The procedure should be to design the circuit as a whole. It will then be found that many of the distortion-producing effects will be acting in opposition and will cancel out, thus providing an adequately good result at minimum cost.

The valve supplying the line or horizontal deflection current generally requires a total cathode current which is of the order of 50 per cent. of that required by the whole of the remainder of the receiver. This current can be reduced by an increase in the efficiency of the various components. This operation adds to the cost, and it is more economical in practice to permit the current to rise somewhat in the interests of component economy.

Any increase in the cathode current of this valve has a negligible effect on the operating cost of the receiver, but it does have an effect on the cost of the high tension current smoothing components, on the size of the high tension rectifying valve, and on the size of the valve itself which has to supply the scanning current. An increase in the cathode current of a valve is not a worry, unless the limit of safe operation is exceeded, in which case the designer might be forced to use a larger and maybe more expensive valve.

The frame or vertical deflection is a somewhat simpler problem, as, owing to the considerably lower operational frequency involved, the duty of all parts involved is less arduous, and the cathode current called for is considerably lower. A very much smaller valve can therefore be used to supply the scanning power required. While a single valve can be used as a saw-tooth generator, as was discussed for the line or horizontal scan, the plea for this circuit is not quite so urgent. In fact the use of single valve generators for both horizontal and vertical deflection, has its own difficulties.

It was stated at the beginning of this paper that good interlacing is most important in the interests of good picture resolution. One of the simplest methods of destroying good interlacing is to permit coupling of any sort between the saw-tooth generating valves. Where the saw-tooth generating valves are followed by amplifying stages, these act as buffers or isolating stages, and it is not difficult to avoid any interference between the line and frame saw-tooth generating valves. Where self-oscillating circuits are used, however, precautions are necessary to ensure that no undesirable coupling exists between the scanning coils on the neck of the cathode ray tube, as this will directly influence the operation.

One method of obviating this difficulty is to refrain from mounting the line deflecting and the frame deflecting coils on a common iron circuit. The frame deflecting coils are removed, and a separate frame scanning unit is used consisting of a vertical

"U"-shaped mounted on the horizontal bar of the "U". This component is mounted part way up the conical part of the tube, which, in addition to raising scanning efficiency, means that the line and frame scanning units are as far apart as possible, thus avoiding interaction.

Another method considered by some designers is to utilise a double triode for frame or vertical deflection, one triode acting as saw-tooth generator and the other triode acting as amplifier. The second triode, acting as an amplifier, becomes a buffer between the self-oscillating line frequency saw-tooth generator and the separate frame frequency saw-tooth generator, thus making the system insensitive to the slight cross-coupling which exists in a cathode ray tube deflection coil yoke of normal type, and permitting it to be used instead of the two separate units just mentioned.

Receiver design

The signal amplifying section of the receiver has an assortment of circuits available. The superheterodyne circuit and the straight signal frequency amplifier each have their adherents. It is probably safe to say that for a single frequency receiver, not expected to operate on very high frequencies, the straight signal frequency circuit is more economical to construct, and equally satisfactory in operation. It falls down on the fact that it is more difficult to make it cover more than a single frequency, and a model with a high order of sensitivity is more liable to suffer from a tendency towards instability if an aerial feeder is used which is not a good impedance match into the receiver input, and which therefore has a worse standing wave ratio.

Whether the final choice be a superheterodyne or a straight receiver, a large history in technical literature will be found as to methods of alignment to achieve the necessary wide bandwidth response curve.

The main methods recommended are:—

1. *Staggered circuits.*

This system calls for some care and trouble in alignment and can suffer from an unstable response curve if any reaction exists over any stage and a valve ages, with a subsequent drop in mutual conductance, or if the contrast control, which operates on the grid bias of some of the amplifying valves is adjusted, thus changing the reaction condition.

2. *Over-coupled bandpass circuits.*

This form of filter usually presents some complexity in alignment, is not easy for the Service Engineer with limited apparatus to adjust, and generally does not repeat precisely from receiver to receiver, unless precautions are taken in the wiring and construction to avoid slight wiring and layout differences around the bandpass transformers.

3. *Low "Q" value circuits.*

All aligned to the same frequency, which is generally the mid-band frequency. This circuit gives a response curve which falls off at the higher modulation frequencies. Correction of this loss of high modulation frequencies is carried out at video frequencies, by suitably resonating the video coupling circuits. This system proves quite satisfactory in service, as alignment is simple and does not present any difficulty to the Service Engineer. The stability of this arrangement is very satisfactory.

4. *Medium "Q" value circuits.*

All aligned to the same frequency, which is generally the mid-band frequency. Negative feed-back is applied over the whole amplifier until the requisite bandwidth is obtained. Alignment of an amplifier of this type is simple, servicing is easy, and the stability is of a high order. On the mechanical side of the design much can be done to keep construction costs low without sacrificing robustness, stability or performance.

The basic chassis should be light in weight, of rigid construction and as compact as is possible without cramping the assembly.

The coils, whether the receiver is of superheterodyne or straight tuned signal frequency type, are relatively numerous, and should be of simple construction. They should be designed to have the requisite value of "Q" without it being necessary to add a damping resistance in parallel, as every unnecessary component added represents an increase in selling price.

The circuits can be aligned either by varying the inductance by means of a high frequency iron core screwing inside the former, or by varying the inductance by means of a copper or brass core screwing inside the former, or by varying the shunt capacity by means of a parallel adjustable trimming condenser. The last method is the worst, as it raises the total capacity across the tuned circuit, which lowers the dynamic impedance of the circuit and thus reduces gain. Every effort should be made to keep the capacity across each tuned circuit as low as possible, providing that whatever adjustment is fitted has adequate range to care for the change in shunt capacity which results from slight differences in wiring layout, and between valves even of the same type.

It is even more important with television receivers than with radio receivers that the valves are secure in their socket during transit, for a customer may re-insert them into the wrong holders, with perhaps disastrous results. The advent of miniature valves assists design in the direction of size and weight reduction, which translates into a cost reduction, providing the valves are not more expensive than those of larger volume. Again the economics have to be balanced.

A fault which has been found in some receivers, and which has frequently been blamed on to the economics of the receiver, but which should in truth be blamed on to the design, consists of the presence of noise streaks across the picture at all times. This interference is self-generated, and is generally caused by a corona discharge existing from some portion of the extra high voltage supply circuit which feeds the anode of the cathode ray tube. It is caused by bad transformer impregnation, by bad lead arrangement, or by having a sharp bend or point somewhere on the high voltage part of the circuit at too close a proximity to the chassis or other metal part.

This type of trouble is very prone to radiate interference into other nearby receivers. Such troubles are bad economically, as they are quickly discovered by the trade and public following which they mitigate against sales and increase service demands.

The mounting arrangements for the cathode ray tube and for the deflection and focus components can become fearfully involved or extraordinarily simple. They can be perfectly effective, or a perpetual risk. Good mechanical design can create a simple structure which satisfactorily performs its several functions. It is wise, when creating one of these designs for the first time, to list the separate requirements, and to provide the answer to each requirement. This procedure ensures that no requirement is overlooked, and also that nothing redundant is added. This last point is frequently just as important.

The correct choice of values for the various controls, both the preset as well as the directly accessible ones, can make for ease of operation combined with adequate range of control to cater for any combined circuit tolerance or valve ageing which may be presented. It should be realised that each circuit into which a control element connects is composed of a number of components together with a valve, or valves, and that each of these items has a maximum tolerance value. According to the law of averages, these tolerances will at times add up in a positive or in a negative direction. The function of a control is to provide a range of control to cover this gap between full positive and full negative, together with sufficient additional range to cater for the other legitimate requirements such as adjustment of any feature of picture presentation.

Appreciation of this requirement, and knowledge of the tolerances and effect of each component in a circuit, permits assessment of any value of a control which is consequence provides the least critical control possible.

A small point, but one which has had two schools of thought almost ever since mains operated radio equipment and moving coil loudspeakers have been used, is whether a receiver should incorporate a permanent magnet type of moving coil loudspeaker, and use a low frequency choke for high tension smoothing purposes, or whether an energised type of moving coil loudspeaker should be fitted, and the field coil of this loudspeaker used for high tension smoothing purposes, thus obviating the need for any additional choke. The tendency seems to tend towards the latter course in modern television circles.

Typical operating conditions demand a loudspeaker field coil of about 60 ohms resistance and some 3 henries inductance at some 200 milliamperes direct current. The reservoir capacity required is of the order of 100 microfarads, capable of carrying about 500 milliamperes of ripple current.

The tube face is protected against the risk of implosion or damage by, in some cases, a sheet of protective glass. This has to have some form of mask behind, generally consisting of a moulded rubber unit. This cost has been reduced in other cases by using instead a front mask pressed from a transparent plastic such as Perspex to the same contour as the tube face, and into which the tube face fits. This mask mounts direct on to the front of the cabinet.

Yet a further development takes the form of a cabinet formed completely from a plastic such as Perspex, the front protective mask being pressed directly out of the panel. While the material is expensive, the cost of manufacture and the tool cost are both low.

Most of the items raised in this brief resume are of a highly controversial nature to engineers, technicians and scientists who have a television interest. The object in presenting them is not to create technical dissension, however interesting that may be, but to make an effort to guide some thought towards means of attracting the maximum volume of interest to television, and if they have caused a few here to stop to ponder, they have served their purpose.

A Panoramic Adaptor with a *Circular* Time Base

(Continued from page 34)

different from 456 k.c., but falling within the 420-500 k.c. range, the alignment procedure is exactly as given above, the alignment procedure is exactly as given above, except that it is necessary to correct the alignment frequencies of the r-f stage and the local oscillator.

Calibration of scale

If accurate frequency readings are desired a calibrated scale may be made up on lucite or other transparent material and placed in front of the cathode-ray tube screen. The scale may be calibrated using a signal generator to determine the desired calibration points. When the signals are obtained directly from a signal generator, it should be remembered that signals from 456 k.c. to 506 k.c. will appear on the left half of the circle, while signals from 456 k.c. to 406 k.c. will appear on the right half. When the signals are obtained from the output of the converter tube in the receiver, signals up to 50 k.c. above the receiver frequency will appear on the right half of the circle and signals up to 50 k.c. below the receiver frequency will appear on the left half.

Correction.

Audio-Frequency Applications of Type 6BE6

When used as an a-f amplifier the 6BE6 has two grids to which a signal can be applied, and for fader-mixer applications it is therefore a useful valve, needing no additional isolating resistors—with their resultant halving of available gain—to reduce interaction of controls.

In addition, with a signal applied to grid 3 the gain obtained from the valve can be varied over a wide range by means of a bias applied to grid 1. This characteristic may be used for volume expansion or in circuits in which it is desired to control gain by electronic means.

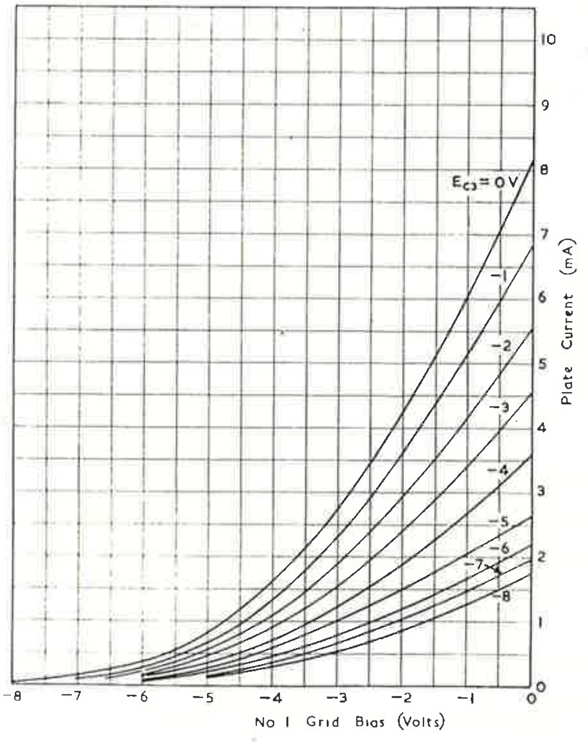


Figure 1

Figure 1. Curves of 6BE6 plate current vs. No. 1 grid bias for fixed values of No. 3 grid bias, E_b = 250V; $E_{c2 \text{ and } 4}$ = 100V.

Figure 1 gives the grid 1 voltage vs. plate current static characteristic of the 6BE6 for different grid 3 voltages, and Figure 2 the grid 3 voltage vs. plate current curves for different grid 1 voltages. For operation over comparatively small plate current excursions the linearity is good, as indicated by the distortion figures shown in Tables I and II.

Figure 3 shows a fader-mixer circuit which gives a gain of 62 from the grid 1 input and 25 from the grid 3 input. Values of measured distortion vs. output voltage for the circuit are as stated; these figures, however, include the a-f generator distortion, which was about 0.1%, so that the distortion from the 6BE6 at low output voltages is actually less than the tables show. At high output voltages most of the distortion is second harmonic.

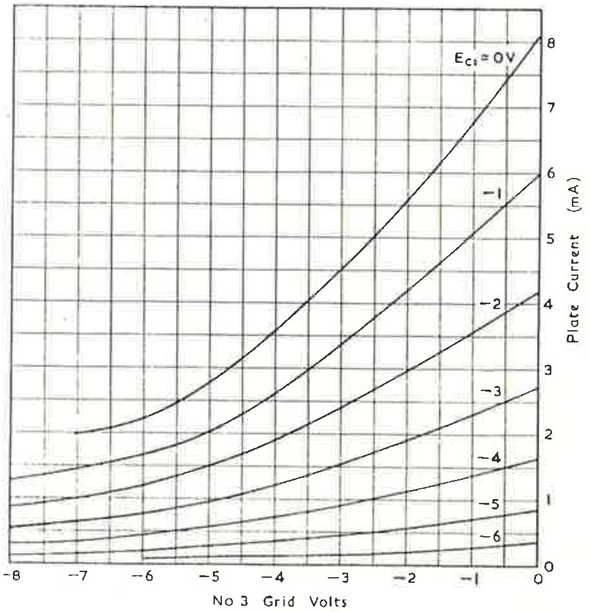


Figure 2

Figure 2. Curves of 6BE6 plate current vs. No. 3 grid bias for fixed values of No. 1 grid bias. E_b = 250V; $E_{c2 \text{ and } 4}$ = 100V.

TABLE I.—Input to grid 1.

Output (volts r.m.s.)	1	5	10	20.
Distortion (%)	0.16	0.19	1.3	3.0

TABLE II.—Input to grid 3.

Output (volts r.m.s.)	1	5	10	20.
Distortion (%)	0.14	1.4	2.6	3.9

Contributed by the Circuit Design Laboratory Valve Works, Ashfield.

The values of the components in Figure 3 are not critical and a reduction of the plate load from 100,000 to 50,000 ohms merely reduces gain to rather more than half the original figure, with a similar reduction of distortion. Higher values of the plate load resistance are not recommended as the distortion becomes excessive. Increasing the value of the bias resistor also decreases gain and distortion proportionately, a 1,000 ohm bias resistor giving about two-thirds of the gain and distortion quoted for 500 ohms. Bias can be obtained by any of the usual methods. Where self-bias is used, the high transconductance of the 6BE6 makes the use of a large cathode by-pass necessary if good low-frequency response is required.

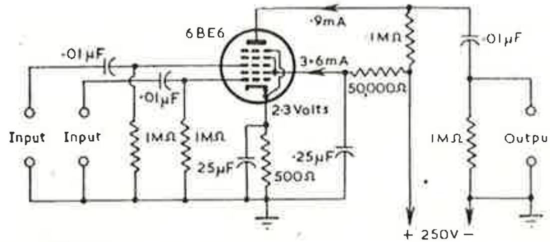


Figure 3

Figure 3. Audio-frequency fader-mixer circuit using type 6BE6.

The screen voltage should not exceed 100 volts, but is not otherwise critical.

For electronic gain control purposes, it is advisable to apply the signal to grid 3 and the control voltage to grid 1. If the signal is applied to grid 1 distortion becomes excessive as the control voltage on grid 3 is increased. In order to determine the range of control available with the signal applied to grid 3 an input of 0.8 volt r.m.s. was used in the circuit of Figure 3 and the bias applied to grid 1 was varied, with the following results:—

TABLE III.

Output (volts r.m.s.)	20	2	0.2	0.02	0.002
Grid 1 bias (volts)	0	−11	−19	−23	−25

With a grid 1 bias of −11 volts the distortion decreased from 3.9 to 2.5%. At lower output levels distortion readings could not be made, and the signal could not be increased greatly without signal grid current flowing. However, at the lower output levels it is unlikely that distortion would increase.

Many applications of these characteristics of the 6BE6 are possible. The measurements tabulated were made on a bogie* valve, but as the characteristics in question are not controlled by the valve specification and are not normally tested in production, it is to be expected that some variation will be experienced from valve to valve.

***A valve having standard characteristics.**

Sub-Miniature Tube

In what is hoped to be a major answer to the problem of reducing the weight and size of its airborne electronic equipment, the U.S. Air Forces' Air Material Command announced at Wright-Patterson, AFB, Dayton, O., that it is developing a "Tom Thumb" synthetic radio tube, about the size of a match head.

Called a "Fieldistor", the sub-miniature tube, which is about 1/90th the size of the present day tube, is now in the early stage of development at the Air Material Command's Components and Systems Laboratory. Colonel Duggar, Components and Systems Laboratory Chief, emphasised that the "fieldistor" is still in the process of development and about 250 have been made, by hand, at present. The new tube offers tremendous advantages from a weight and space standpoint—an all-important factor in aircraft equipment. In appearance, it resembles the end of an eye dropper, and ten of them could be carried in an ordinary thimble.

There is possible adaptation of the small tube to civilian usage in such items as radio, television, hearing aids, fire and burglar alarms, thermostats, etc. But Colonel Duggar said that he did not expect to see any of the new devices in civilian items for some time. It was pointed out that the tube is still a bit too noisy and the cost in hand production is too high, but with mass production methods the cost could come down to a reasonable price.

The small size and structure of the "fieldistors" will also enable them to withstand better engine vibration, gunfire and landing shock, which literally shakes the life out of the conventional tube. Since modern aircraft uses hundreds of tubes in its radio and electronic and radar equipment, the space and weight saved by the "Tom Thumb" devices means longer aircraft ranges at reduces operating cost. Another big advantage of the new tube is that it uses so little current that most batteries can be eliminated and only one small battery used.

Reprinted from "Signal" by courtesy of the Armed Forces Communications Association, U.S.A.

Electronic Timers

By E. A. Demonet and L. C. Bower.

Introduction

Before discussing the factors entering into the design of various types of electronic timers, other electrical methods of producing time delays in contact operation, and their limitations, will be described for purposes of comparison.

Slug relays

Short time intervals of delay, before or after an external occurrence, may be secured by electromagnetic relays having copper core slugs (a short-circuited turn of large cross-section) whose size and position on the relay core, as well as the relay's complement of contacts, establish the delay interval. These intervals are in the order of 10 to 400 milliseconds.

Dash-pot relays

Longer time intervals of seconds in length may be secured by dash-pot relays, in which the operation of contacts by a solenoid is retarded by a plunger whose movement in a cylinder is determined by the rate at which air or oil is permitted to pass from one side of the plunger to the other. When the solenoid is de-energized, the return of the plunger is speeded by the opening of a release valve in the plunger. This restoration, however, is of appreciable duration which makes this type of relay inapplicable where a very rapid restoration is essential.

Thermoelectric relays

Time intervals of similar or greater length can be secured by the use of a thermoelectric relay or "flasher". This device comprises a heating coil which encloses a bimetal strip at one end and provided with a contact point at its opposite or free end. Under the influence of heat, this strip deflects from a stationary back contact to a front contact thus opening the circuit from one contact and closing it to the other. The opening of the heater coil circuit allows the bimetal strip to cool and move to its original position and back contact connections. The coil may be arranged in an external circuit, or in series with or in shunt with the contacting strip. This device is not satisfactory for applications requiring uniform operation because it is subject to the surrounding temperature and heat resident from previous operations.

Reprinted from Western Union Technical Review, Vol. 4, No. 3, July, 1950.

Electronic timers

The so-called electronic timer is a device employing a thermionic electron or vacuum tube with a network of capacitors and resistors connected to the grid, or starter anode (to obtain the timing desired) and usually a relay connected into the plate circuit of the tube to control external circuits. Electronic timers are not influenced to any appreciable extent by surrounding temperatures or heat resident from previous operations and, in addition, return almost immediately to their initial condition after release.

Electronic timers may be divided into two general classifications—those using "hot-cathode" tubes and those employing "cold-cathode" tubes. The three special types chosen for description in this paper have widely differing abilities; one responds to signals of one duration, one produces signals of two durations and the other responds to signal of two durations.

Hot-cathode type

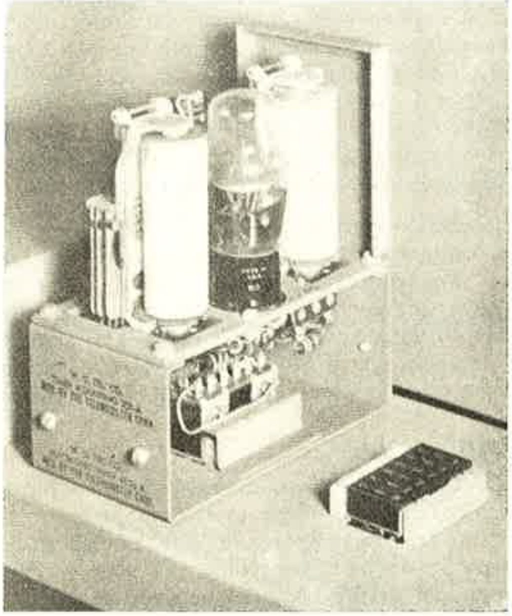
The hot-cathode vacuum tube timer requires a continuous external supply of electric energy to heat the cathode to a temperature high enough to emit electrons. In this type of tube, the plate current is proportional to the potential between the grid and cathode when above the cut-off point on its characteristic control grid potential-plate current curve. By changing the potential on the grid, the plate current can be varied from no current flow to a maximum, the actual values being dependent upon the tube employed and the characteristics of the plate current.

Cold-cathode type

The cold-cathode type of timer uses a three-element (cathode, plate and starter anode) tube in which an inert gas, under low pressure, is enclosed in an envelope. This type of vacuum tube does not require a continuously heated cathode to supply the electron emission. The cathode in these tubes usually is coated with an oxide which emits electrons more readily than a metallic surface. When the starter anode is made approximately 85 volts, positive (in the case of an OA4G tube) with respect to the cathode, ionization of the enclosed gas takes place providing electrons to bombard the cathode. The cathode then provides electrons in sufficient quantity to establish a conducting path to the plate. If the plate has a positive potential in excess of 60 volts with respect to the cathode, the tube "fires" and begins to pass plate current.

The starter anode is used only to initiate the flow of plate current. Unlike in the case of the hot-cathode grid-controlled vacuum tube, the starter anode voltage has no control over the plate current once the tube has fired. The voltage may even be removed from the starter anode and the tube will continue to conduct.

The plate current will instantly reach a maximum value after the tube has fired. In order to stop the flow of plate current, the cathode-to-plate voltage must be reduced below a finite value dependent on the type of tube (60 volts in the case of an OA4G tube). This type of tube is often "extinguished", or made non-conducting, by opening the plate circuit.



Cold-cathode type electronic timer.

Operate interval

In circuits employing either type of vacuum tube mentioned above, the same principle is used to determine the operate interval, which is the time required to operate or release the plate circuit relay after a potential of correct polarity has been either applied to or removed from the network of capacitors and resistors connected to the grid or starter anode of the tube.

There are three factors to be considered when determining this operate interval. The first is the firing or cut-off time of the vacuum tube employed. The second is the operate or release time of the plate relay. These two factors have a limited range and are fixed at the time of design when components are chosen. The third and most easily controlled factor is the value of the capacitors and resistors in the combination connected to the grid or starter anode of the tube.

The firing time is in the order of micro-seconds for hot-cathode and up to 4 and 5 milliseconds for cold-cathode tubes. Unless the requirements for the timer include a high degree of accuracy or an operate interval in the order of milliseconds, the firing time of a tube is negligible.

A practical relay also is limited as to its operate time and the range over which it may be varied, and as to the maximum time the relay may consume in operation. The operate time of standard switching type relays will provide for relays of approximately 4 to 10 milliseconds by the choice of relay. Here again the choice of relay depends upon the accuracy and length of time desired for timer operation. As the time delay introduced by a given relay depends upon the pressure of the contact spring complement and magnetic circuit, it is not easy to adjust the relay for a particular operate time.

The third factor is the one most convenient for establishing and refining the adjustment of the operate interval length. By proper selection of resistor and capacitor values, large or small time intervals in excess of the limitation of the other factors, may be secured.

When a capacitor is charged through a resistor, the capacitor does not become charged immediately but will approach that value in a time depending on the values of the resistance and capacitance combination employed. Conversely, if a charged capacitor is discharged through a resistor, it takes a certain amount of time, dependent on the values of resistance and capacity, to fully discharge the capacitor.

Actually, a capacitor can never be charged to the voltage applied across its terminals, due to losses through the interplate dielectric. On discharge, however, the voltage between terminals of a given capacitor will reach zero in a time determined by the value of resistance connected between the terminals.

The rate at which a capacitor is charged through a resistor by application of a fixed potential is not uniform but is greatest at the start and reaches a value of 63.2 per cent. of maximum after an elapsed time of T seconds. The finite value of T, or the time constant of a resistor-capacitor circuit, is the product of the resistor value in ohms and the capacitor value in farads, or $T = RC$.

Similarly, if a capacitor C charged to a voltage E is discharged through a resistance R, it will have a charge or voltage of $(1 - 0.632)$ or $0.368\ E$, RC seconds after the start of the discharge.

The instantaneous voltage across any capacitor of an RC circuit may be calculated mathematically from the equation:

$$V = E\ (1 - e^{-T/RC}) \quad . \; . \; . \; . \quad (1) \text{ where:}$$

V = instantaneous voltage across capacitor

E = applied voltage

$$e = 2.718 = (1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \ldots)$$

= Base of Natural Logarithms

T = time in seconds from the instant that the voltage E is applied.

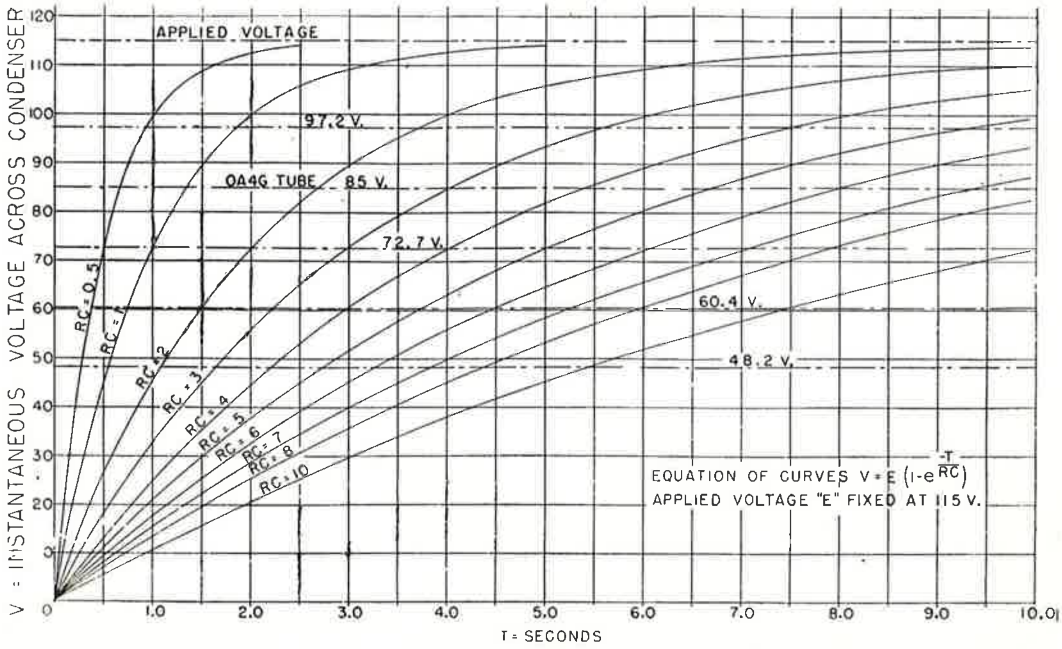


Figure 4. Instantaneous capacitor voltage while charging

The value of 0.632 may be obtained when $T = RC$ by substituting RC for T in the equation above and solving for V in the following manner:

$$V = E\ (1 - e^{-RC/RC}) = E\ (1 - e^{-1})$$

$$= E\ (1 - 1/e) = E\ (1 - \frac{1}{2.718})$$

$$= E\ (1 - 0.368) = 0.632E \ \ldots\ldots\ (2)$$

In effect, this result shows that no matter what the applied voltage, at the time $T = RC$, the voltage across the capacitor of an RC circuit will be 63.2 per cent. of that applied voltage.

Formula (1) includes four variables (V, E, T and RC). If the value of E is fixed at the average line voltage of 115 volts, the three remaining variables may be plotted, resulting in the family of curves for RC shown in Figure 1. This set of curves shows that with a fixed applied potential, the smaller the RC combination the faster the voltage across the capacitor builds up.

At the time $T = RC$ (which occurs at 63.2 per cent. of 115 volts or 72.7 volts) there is a horizontal dash line shown on the graph. This line intersects each RC curve at one point. At 85 volts (the firing voltage for an OA4G tube) another horizontal line is shown intersecting each RC curve at one point. By taking a series of these horizontal lines at selected firing voltages, voltages on Figure 2 may be obtained.

This set of curves shows that at a fixed applied voltage of 115 volts, the product $R \times C$ for electronic tubes firing at voltages higher than 72.7 volts (63.2 per cent. of 115 volts applied) is less than the time T, and for those tubes with firing voltages less than the time T. The designated constants by which RC must be multiplied, in order to obtain the required time, are indicated on the curves shown on the graph (Figure 2).

Figure 3 shows the family of curves for time when plotted against RC and the theoretical firing voltage required for different tubes. This graph is a convenient chart for determining the value of RC required if the applied voltage is 115 volts and the firing voltage of the tube and the desired time are known. Interpolation may be made directly between the time curves in the vertical direction.

Typical Electronic Timers

Timer responding to one timed interval

Figure 4 shows a typical circuit for a cold-cathode type of timer that responds to a timed signal. In this case, the timing is initiated by the operation of the relay E. The result desired is to operate the plate circuit relay P a given time after relay E has operated. By use of contacts on relay P, the control of some external circuit may be accomplished.

The actual length of time consumed between the operation of relay E and relay P is controlled by the capacitor C and resistor R. The 0.24-megohm resistor merely acts as a current limiter for the protection of the starter anode. The 0.05-microfarad capacitor serves to maintain the voltage at the starter anode at the instant the current starts to flow from the starter anode to the cathode. Without this capacitor the voltage at the starter anode would drop as current began to flow through the 0.24-megohm resistor to the cathode. The capacitor takes a charge when relay E is operated and at the instant the current starts to flow from the starter anode to the cathode, the 0.05-microfarad capacitor discharges to increase the current flow to assure the immediate firing of the tube.

The values of capacitor *C* and resistor *R* determine the length of time it takes the tube to fire after relay E has operated. By selecting the correct values of *R* and *C*, the firing of the tube (and consequently the operation of relay P) may be delayed by the desired time after relay E operates.

In this instance, the firing voltage of the OA4G tube is known to be approximately 85 volts, and the desired operate interval of the timer to be between 4 and 5 seconds. Since the operate interval is in seconds and the tolerance on the time is not exacting, the firing time of the tube and the operate time of the plate relay may be neglected.

With the above information, the *RC* product may be found from the curves on Figure 3. At the vertical line indicating the firing voltage of 85 volts, interpolation between the curves of 4 seconds and of 5 seconds is made to determine the point for $4\frac{1}{2}$ seconds (half way between the specified values). When this point has been located, the product *RC* is found by projecting a horizontal line over to the *RC* axis and reading the result directly. In this case, the product of *R* and *C* must be approximately 3.3.

The next consideration is what values to make *R* and *C* to obtain the 3.3 result. Although there is an unlimited theoretical combination of values for *R* and *C*, which when multiplied together will equal 3.3, the practical values and dimensions of standard manufactured resistors and capacitors must be taken into account. Another consideration must be the standard tolerance on the resistors and capacitors.

Assume that a 2-microfarad capacitor fits the qualifications for physical size, rated voltage, etc. In order to obtain $RC = 3.3$, the resistor then must be 1.65 megohm. Since 1.65 is not a standard size, the nearest standard size (1.8 megohm) is used, resulting in an *RC* combination of 3.6. Working in the reverse direction on the chart of Figure 6 an *RC* combination of 3.6 gives an operate interval of about 4.7 seconds at 85 volts firing voltage. The practical result obtained satisfies all the requirements of the timer. Should an exact value of $4\frac{1}{2}$ seconds have been desired, the resistor would have been an adjustable unit or a standard fixed unit in series with an adjustable one.

Timer producing either of two timed intervals

Figure 5 shows the circuit for a hot-cathode type of timer which produces either of two timed intervals. If relays E1 and E2 are operated 600 milliseconds later relay P will operate.

The 0.1-megohm resistor in series with the lower grid of the 50L6-GT vacuum tube is a current limiter provided to protect that grid from high current. The upper grid (called the screen) reduces the capacity between the lower grid and plate of the tube and

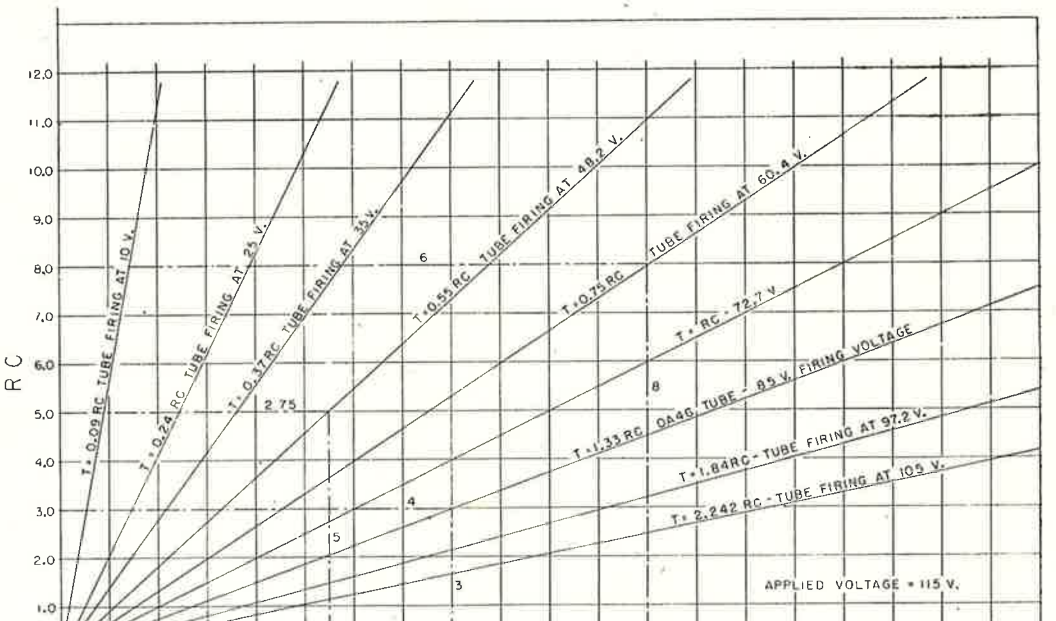


Fig. 2. Required R × C vs. time delay (firing voltage at capacitor).

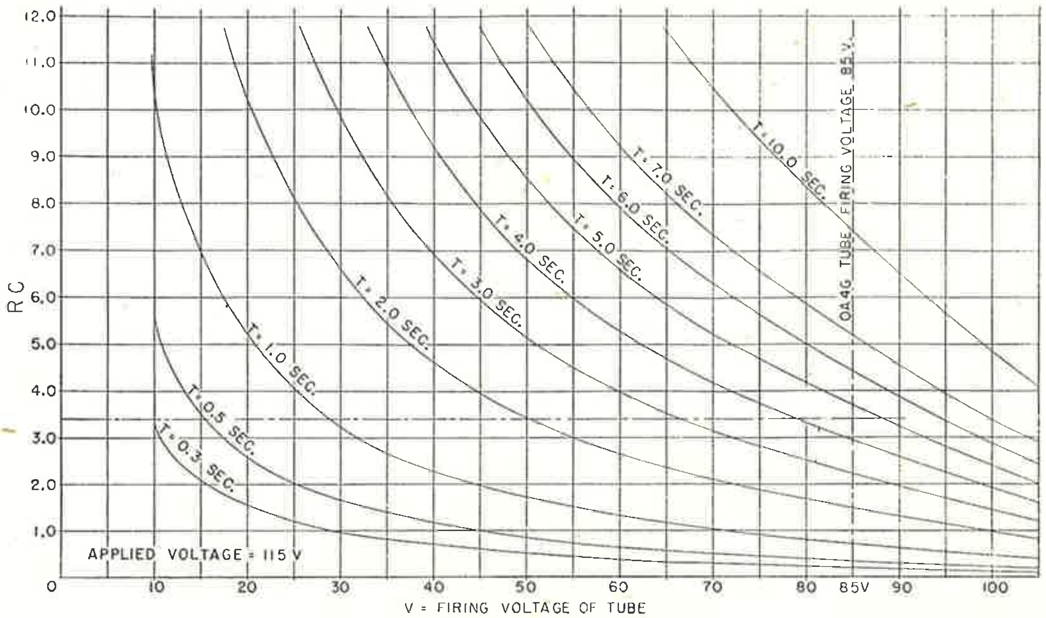


Fig. 3. RC vs. firing voltage of tube (also voltage at capacitor being charged).

also makes the plate current practically independent of plate voltage within the range of its operation. The screen is connected to positive battery through 10,000 ohms, thereby attracting electrons from the cathode. However, most of the electrons drawn to the screen pass through it to the plate because there is comparatively large spacing between the wires of the screen. The result is a faster build-up of plate current than would have been obtained in a triode type of tube (one using only plate, cathode and grid).

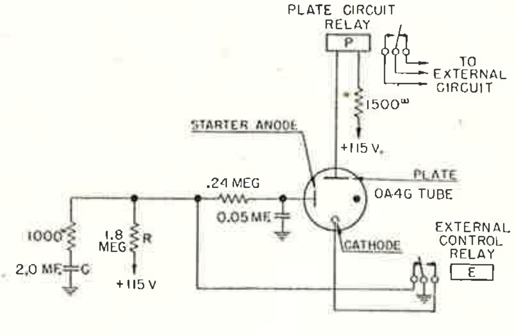


Fig. 4. Typical circuit for a cold-cathode type of timer which responds to one timed interval.

Also the 50L6 tube is constructed to beam electrons from the cathode to the plate to aid in a more rapid build-up of plate current. Thus, the time required, due to the tube construction, to build up the current through the coil of relay P, has been minimized by the selection of this type of tube.

The curves given herein are for the charge of a capacitor. From a similar group of curves plotted to show the discharge of a capacitor the values of the resistors $R1$ and $R2$ and capacitor C can be determined for the time $T = 600$ milliseconds which is obtained when relays E1 and E2 are both operated. Also the value of resistor $R3$ can be determined which, when added to $R1$ and $R2$ with relay E1 operated and E2 released, would produce a timed signal of T = 2 seconds.

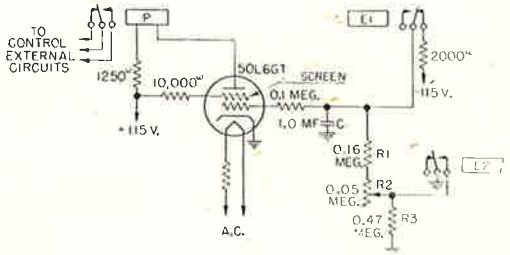


Fig. 5. Typical circuit for a hot-cathode type of timer which produces either of two timed intervals.

In order to obtain a higher degree of accuracy for the operate interval, $R2$ is made a variable resistor. By varying this resistance the ageing of the tube, interchanging of tubes, and variations due to manufacturing tolerances in the resistor and capacitor values, as well as the supply voltage encountered, may be easily compensated for and the desired operate interval obtained.

Timer responding to two timed intervals

Figure 6 shows the circuit for a cold-cathode type of timer which responds to two timed signals. If relay E is operated, 500 milliseconds later relay F

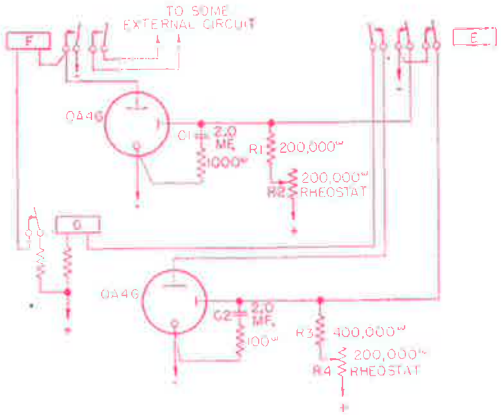


Fig. 6. Typical circuit for a cold-cathode type of timer which responds to either of two timed intervals.

will operate and lock up, closing a path for some external circuit. If relay E is not released within 1½ seconds after relay F operates, relay G will operate and open the lock circuit for relay F, which, in turn, opens the path to the external circuit.

If, on the other hand, relay E is released within 1½ seconds after relay F operates, the path to the external circuit will remain closed until 2 seconds after relay E is re-operated. Relay G will then operate and open the lock circuit for relay F and in turn open the path to the external circuit. Then when relay E is released, the timer will be reset to its normal state. Here, again, the values for $C1$ and $R1$ plus $R2$ can be found from the curves of Figure 6 for $T = 500$ milliseconds at the firing voltage for an OA4G tube. Also the values for $C2$ and $R3$ plus $R4$ can be determined for $T = 2$ seconds $R2$ and $R4$ are variable resistors for setting the operate time to a specific value. These variable resistors permit compensation for variations in the timer components and supply voltage.

New RCA Releases

Radiotron type 5915—is a 7-pin miniature pentagrid amplifier designed especially for gated-amplifier service Grid No. 1 and No. 3 can be used as independent control electrodes.

This type has been designed for reliable performance in "on-off" control applications, such as electronic computers, involving long periods of operation under cutoff conditions. In such service this type will maintain its emission capabilities even after long periods of operation at cutoff. In addition, this type features freedom from grid emission and consistency of cutoff bias.

The 5915 is not intended for applications critical as to microphonics, nor is it, in general, superior to other types for conventional amplifier or converter service in which they might be used.

Radiotron type 5963—is a medium-mu twin triode of the 9-pin miniature type intended particularly for frequency-divider circuits. It has a centre-tapped heater to permit operation from either a 6.3 volt or 12.6 volt supply, and separate connections for each cathode to provide flexibility of circuit arrangement. The 5963 has a maximum plate dissipation of 2.5 watts.

Radiotron type 5964—is a 7-pin miniature medium-mu twin triode for use in frequency-divider circuits. Its cathode is common to the two triode units. The 5964 has a maximum plate dissipation of 1.5 watts.

Radiotron type 6S4—is a high-perveance, medium-mu triode of the 9-pin miniature type. In suitable vertical-deflecting circuits, the 6S4 will deflect fully a 16GP4 or any similar kinescope having a deflection angle up to 70° and operating at an anode voltage up to 14 kilovolts.

Radiotron type 7NP4—is a projection kinescope for theatre television. It projects a clear, bright picture of 20 feet by 15 feet, when used with a suitable reflective optical system. The 7NP4 employs electrostatic focus and magnetic deflection. It operates with a maximum anode voltage of 80,000 volts and a maximum focusing-electrode voltage of 20,000 volts.

Radiotron type 10BP4A—is an improved type 10BP4. It uses a "Filterglass" face plate, which has essentially uniform transmission over the visible region of the spectrum. The average value of transmission is 66%.

Radiotron type 12LP4A—is an improved type 12LP4, using a "Filterglass" face plate.

Radiotron type 16AP4A—is an improved type 16AP4, using a "Filterglass" face plate.

Radiotron type 5826—is a television camera tube intended for studio use and other television applications where the lighting can be controlled. It combines exceptionally high sensitivity, a resolution capability of better than 500 lines, high signal-to-noise ratio, and improved grey-scale rendition in the vicinity of the "blacks".

The 5826 is a companion to the outdoor pickup type 5820. Use of the 5826 in the studio and the 5820 outdoors facilitates the combination of indoor and outdoor pickups on the same programme.

This type can be substituted to advantage for the earlier studio type 5655.