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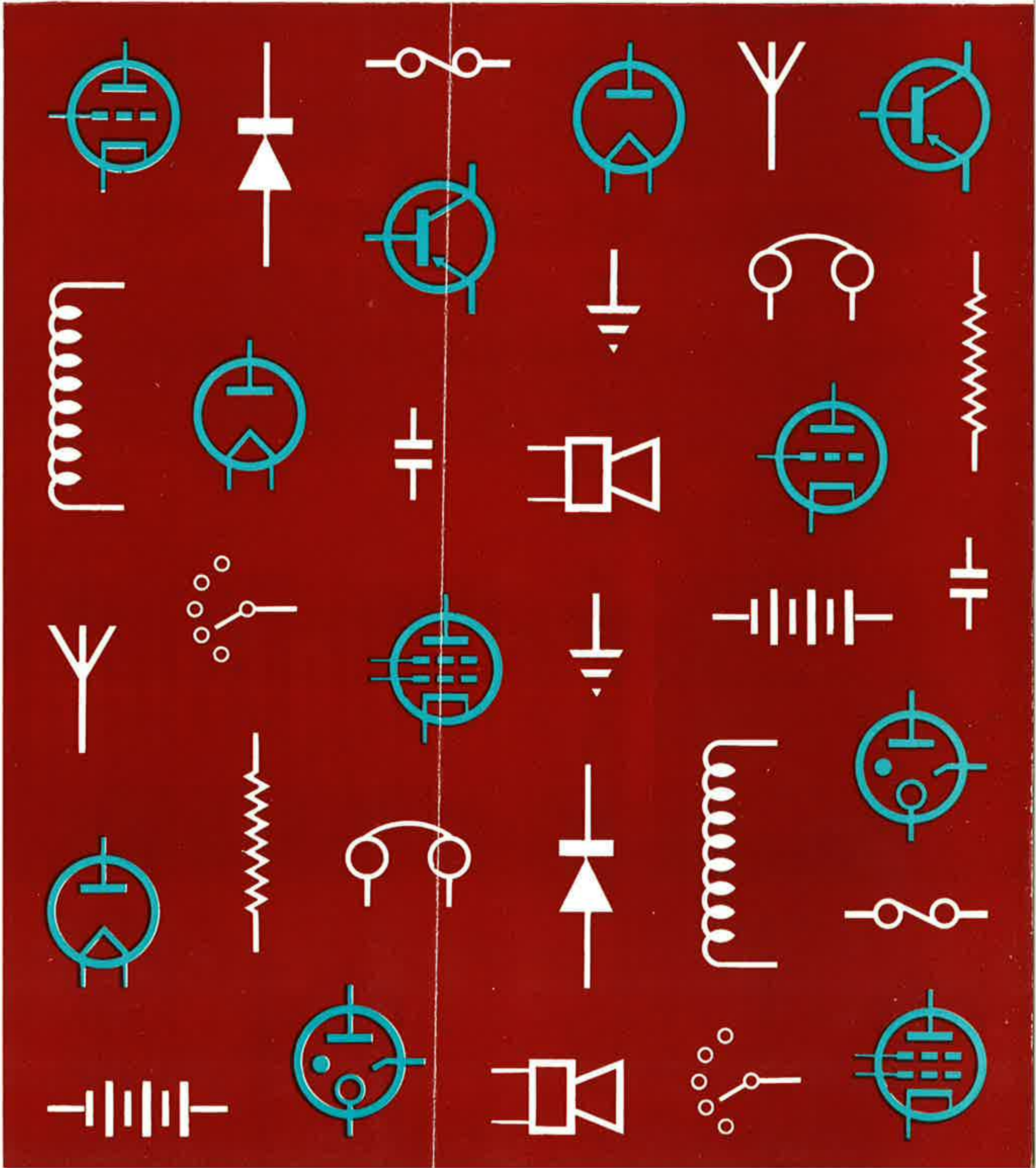

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RADIOTRONICS

Vol. 25, No. 11, 1960

Editor, Bernard J. Simpson

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BANDPASS TRANSMITTER-EXCITER USING THE 6146

By Richard G. Talpey, W2PUD*

Are you planning to build a new VFO, an all-band exciter, or a pi-network final? If so, we're sure that you will find it very worthwhile to read W2PUD's article before you begin. It is intended for those readers who want to build something other than a conventional transmitter.

This article differs from the usual how-to-build it descriptive article in that it features a thorough discussion of the "groundwork" that preceded the final design. Because of the enthusiasm with which the active ~~ham~~ amateur reads such a discussion, and the improbability of the average ~~ham~~ amateur copying this transmitter to the last detail, this article has been divided into two parts. The first part contains a description of the transmitter; the constructional details appear in the second part. This arrangement provides ample space for the author to expound on some very interesting ideas on the design of a modern mutiband rig.

TECHNICAL DESCRIPTION

The excellent performance of the 6146 beam-power amplifier at high frequencies, its maximum ICAS rating of 90 watts input for cw operation, its very low driving-power requirement (0.3 watt), and the elimination of the need for special shielding make this valve the logical successor to the 807 for use in an exciter of modern design.

General Requirements

Early in the project, it was decided that the transmitter-exciter to be built around the 6146 should have the following features: (a) operation on the 3.5-, 7-, 14-, 21-, and 28-Mc bands by means of a single bandswitch and VFO; (b) provision for break-in operation; (c) freedom from TVI; (d) reasonably simple construction; (e) minimum of valves and controls.

The transmitter shown in Fig. 1 provides all of these features. For ease of operation, this unit requires no tuning other than the VFO and the final tank; broadband double-tuned tank circuits are used in the exciter stages, and a tapped pi-L tank circuit provides flexible TVI-proof operation of the final amplifier. A keyed amplifier between the VFO and the first frequency multiplier eliminates any back-wave and permits full break-in operation.

An output of 65 watts cw or 45 watts AM phone is available on all bands. † Power requirements are 6.3 volts ac at 4.1 amp, 250 volts dc at approximately 100 ma for the exciter stages, and either 600 volts at 150 ma or 750 volts at 125 ma for the final amplifier. The 6146 operates well at reduced plate voltages and can be run at the full rated plate current of 150 ma.

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* Tube Dept., Radio Corp. of America, Harrison, N.J.

† See bottom of next page.

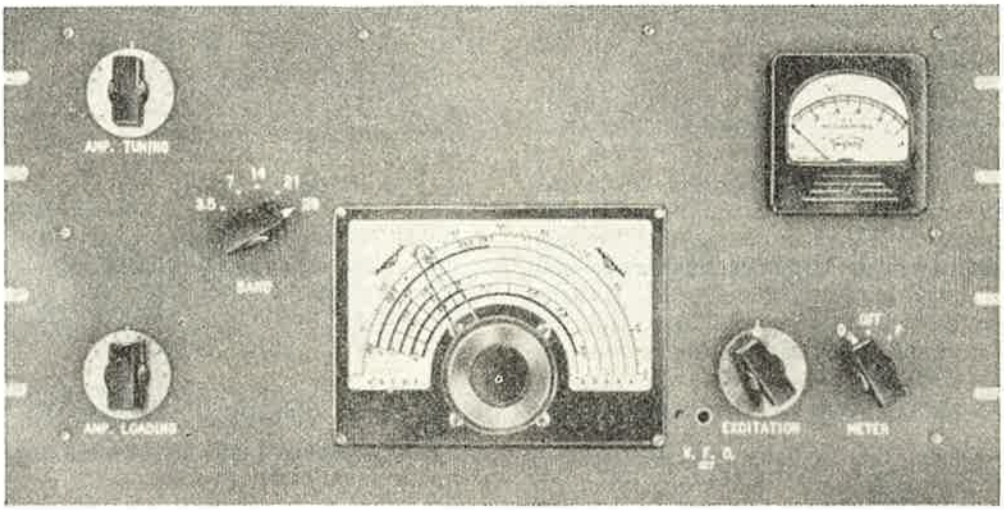

Fig. 1 — Pick your band, set the VFO, tune and load the final, and you have an output of 65 watts for AM phone operation.

Design Considerations

Heterodyne VFO

Keeping in mind the general requirements of the rig, the first consideration was the VFO. Initially, a heterodyne-type VFO was investigated to obtain break-in operation. This unit used an 8.5-Mc crystal beating with a VFO which tuned from 4.5 to 5 Mc to provide output over the 3.5-Mc band.

Several circuits were moderately successful, providing sufficient output and good keying in the mixer stage. Although these tests were carried out on the bench with rather haywire unshielded circuits, it was possible to eliminate the receiver backwave almost completely when the key was up. One of these circuits used a 6AK6 Clapp VFO, a 6C4 crystal oscillator followed by a 6AU6 buffer and a 5763 mixer. The 6AU6 was keyed and a bandpass tank circuit was employed in the output of the mixer to attenuate the unwanted sideband and the two oscillator frequencies. The use of the 5763 as a mixer, however, required that an amplifier be used to bring the signal up to the proper level to drive the final on 75 metres.

The original lineup, using a 5763 amplifier/multiplier and 5763's in all of the multiplier stages, was viewed with some misgivings because the 5763 oscillated when operated as a straight-through amplifier. Various neutralization circuits were applied to the 5763 without success, the chief difficulty being the maintenance of proper phase opposition in the band-pass coupling circuits over the fairly large bandwidth of the 3.5-Mc band.

An even more serious difficulty arose when the band-pass tank circuit provided inadequate filtering thereby permitting a complex signal (containing both oscillator signals and their sidebands) to be applied to an amplifier which had to be driven hard enough to draw grid current (and thus present a non-linear impedance). Although the desired sideband was partially filtered out in the previous stage, there was sufficient voltage present at the unwanted frequencies, and the heterodyne signal which resulted from this non-linear mixing could only be characterized as a mess.

A little reflection shows that nothing other than the above results can be predicted when a high-level mixing system is used unless a filter having rigid requirements is used in the output of the mixer. (It is entirely possible to build a successful heterodyne VFO; several have already been described in the amateur radio literature.) Mixing is best accomplished at low level, where unwanted sidebands can be filtered more easily without too much shielding.

The advantage of a mixer VFO lies mainly in the ease of keying and obtaining break-in, and in the stability which is gained by allowing both

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[†] The reader may ask why the frequency range of this transmitter does not include the 11-metre band. Considerable thought and experiment went into this possibility. In order to cover 3.3 to 4 Mc with a double-tuned circuit, the Q must be lowered to a value that makes the proper degree of coupling between coils very difficult to obtain; furthermore, the skirts of the response curve of the stage would be fairly broad. It was felt that the advantages of 11-metre operation do not justify the increased complexity or compromises in the design, e.g., an extension of the tuning range of the VFO down to 3.3 Mc results in the 14-Mc band occupying a smaller section of the dial.

oscillators to run continuously. However, there are other ways to accomplish the same result with much simpler circuits.

Shielded VFO

The VFO finally chosen for this transmitter is one that has been in use in the author's shack for several years. The system is not novel; in fact, it has been used in several commercially-built transmitters, and has been described in the literature.* The VFO operates on 1.7 Mc. Sufficient shielding is employed so that it can be run continuously — keying is accomplished in the first amplifier stage following the oscillator.

In this system, the oscillator must be relatively free from harmonics and the design must not include any non-linear circuits between the VFO and the keyed stage. The VFO employs a Clapp oscillator which is especially suitable for this application because it is very stable; also, it is essentially a weak oscillator having a rather high Q and very little harmonic output. The particular variety of Clapp VFO chosen for this application has been described previously.** By running the oscillator at low plate voltage (40 volts) and following it with a high-gain keyed stage, it is possible to reduce the radiation to almost nil, so that the VFO may be run continuously without interference when the key is up.

VFO and Keyed Amplifier

The complete circuit for the transmitter is shown in Fig. 3. The Clapp oscillator uses a single section of a 12AU7; the other section of this valve is a cathode follower which provides a low-impedance output that "can be led around the chassis" through a shielded cable to the grid of the 6AU6 keyed amplifier.

The use of a high-gain keyed amplifier makes it possible to operate the VFO with an output voltage of about 1 volt, thereby making the shielding problem easier to solve.

It was found desirable to mount the coupling capacitor and grid leak for the keyed-amplifier stage inside the oscillator shield compartment. This arrangement permits a short (¼-inch) length of signal lead to be exposed for connection to the

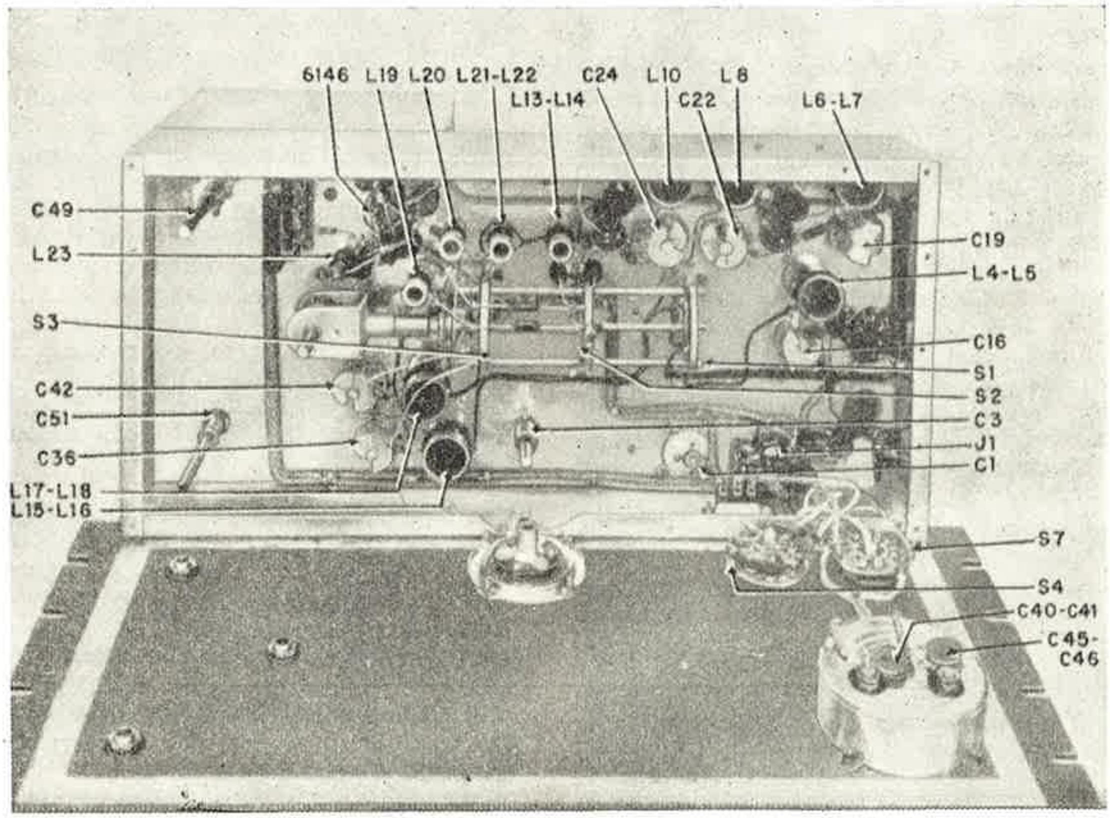

Fig. 2 — Inside view of the transmitter. Note the area where the paint is removed from the panel for contact with the chassis. Also note the meter shield, the meter bypass capacitors, and the shielded power leads, all essential TVI precautions.

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* "A Solution to the Keyed-VFO Problem," by R. M. Smith, W1FTX, QST, Feb. 1950, page 11.

** "Some Notes on the Clapp Oscillator," by R. G. Talpey, W2PUD, QST, Jan. 1949, page 45.

grid of the keyed amplifier. Simple by-pass and decoupling networks, in the power leads to the VFO compartment, plus the use of shielded wire for power wiring leaves little possibility for leakage from the oscillator.

The 6AU6 high-gain keyed amplifier operates close to class-A conditions. It provides good shielding and enough output to drive a 5763 (first doubler) which doubles to 3.5 Mc. Impedance coupling is used between the 6AU6 and the first doubler to reduce the number of tuned circuits.

Coupling Methods For Bandpass Operation

In this transmitter, bandpass coupling circuits are used to eliminate the need for retuning the multiplier stages when the frequency of the VFO is changed. This arrangement was employed (instead of ganging the tuning controls of the multipliers with the VFO dial) to avoid a tracking problem and to minimize the number of restrictions on the physical layout of the exciter.

Broadband Tank Circuits

Although broadband resistance-loaded tanks were used in the past, they are no longer recommended because they are rather unsatisfactory for TVI reduction. The low Q's involved do not provide sufficient skirt selectivity and the possibility of transmission of several harmonics of the multiplier frequency can lead to possible misadjustments and considerable harmonic output.

Several exciters using broadband, double-tuned tanks in the multiplier stages have been described in the literature. All of these exciters employ critically-coupled or over-coupled transformers to achieve the broadband performance. The primary and secondary windings of such transformers can be wound on the same coil form or mounted close to each other with their axes parallel.

When this type of transformer is adapted to a bandswitching system, either of two undesirable conditions usually arises: (1) The number of multiplier stages is increased because of the necessity of switching particular stages in or out of the lineup to obtain the correct output frequency. (2) The complexity of the switching necessitates a compromise in the physical layout.

When adjoining multiplier stages have their coils mounted close to each other (with their axes parallel), sufficient coupling can be provided if the Q's of the coupled circuits can be made high enough to obtain the proper coefficient of coupling.

Link-Coupled, Double-Tuned Coupler

If the primaries and secondaries of the tuned transformers are coupled by low-impedance links, it becomes feasible to build a broad-band exciter covering 3.5 through 28 Mc with only two or, at the most, three valves — the usual number required for a conventional exciter. The parts may be arranged for maximum efficiency and short leads, and the link switch may be mounted almost anywhere because it switches only low-impedance circuits.

The link-coupled, double-tuned coupler is considerably easier to adjust than the direct-coupled type because there are no large windings to be moved up and down on the coil forms. The links may be wound with stiff wire and conveniently slid over the primary and secondary windings. After the coupling is adjusted, the links may be cemented in place.

In this transmitter, it was found convenient to use three different coupling methods; the choice of a particular coupling method for a given portion of the circuit was determined by the layout and required bandwidth.

Bandswitching the Multipliers

The grid of the final amplifier is switched to any of five resonant circuits by bandswitch S3 and the drive is selected from the appropriate multiplier stage. The first 5763, doubling from 1.7 Mc, drives the final on 3.5 Mc. The link that is coupled to the plate circuit of this doubler is switched by S1A to either the final grid circuit or the second doubler, a 5763 having its grid circuit tuned to 3.5 Mc. The output of this doubler is link coupled through switch S1B to the final for 7-Mc operation.

The plate coil of the second doubler is mounted close to the 7-Mc grid coil of the third multiplier so that the two stages are coupled inductively without the use of a link circuit. This third multiplier is used to double, triple, or quadruple for output on 14, 21, or 28-Mc, respectively.

On 14 and 21 Mc, where the percentage bandwidths are small, the resonant circuit selected by S3 functions as the tank. A choke (L11 or L12) is used to feed plate voltage to the multiplier, and capacitance coupling is used between this multiplier and the grid circuit of the 6146.

On 28 Mc, the multiplier plate circuit is tuned by means of a slug in L13, resonating with the valve capacitance. A link is run permanently to grid tank L22, which is also slug tuned. Link

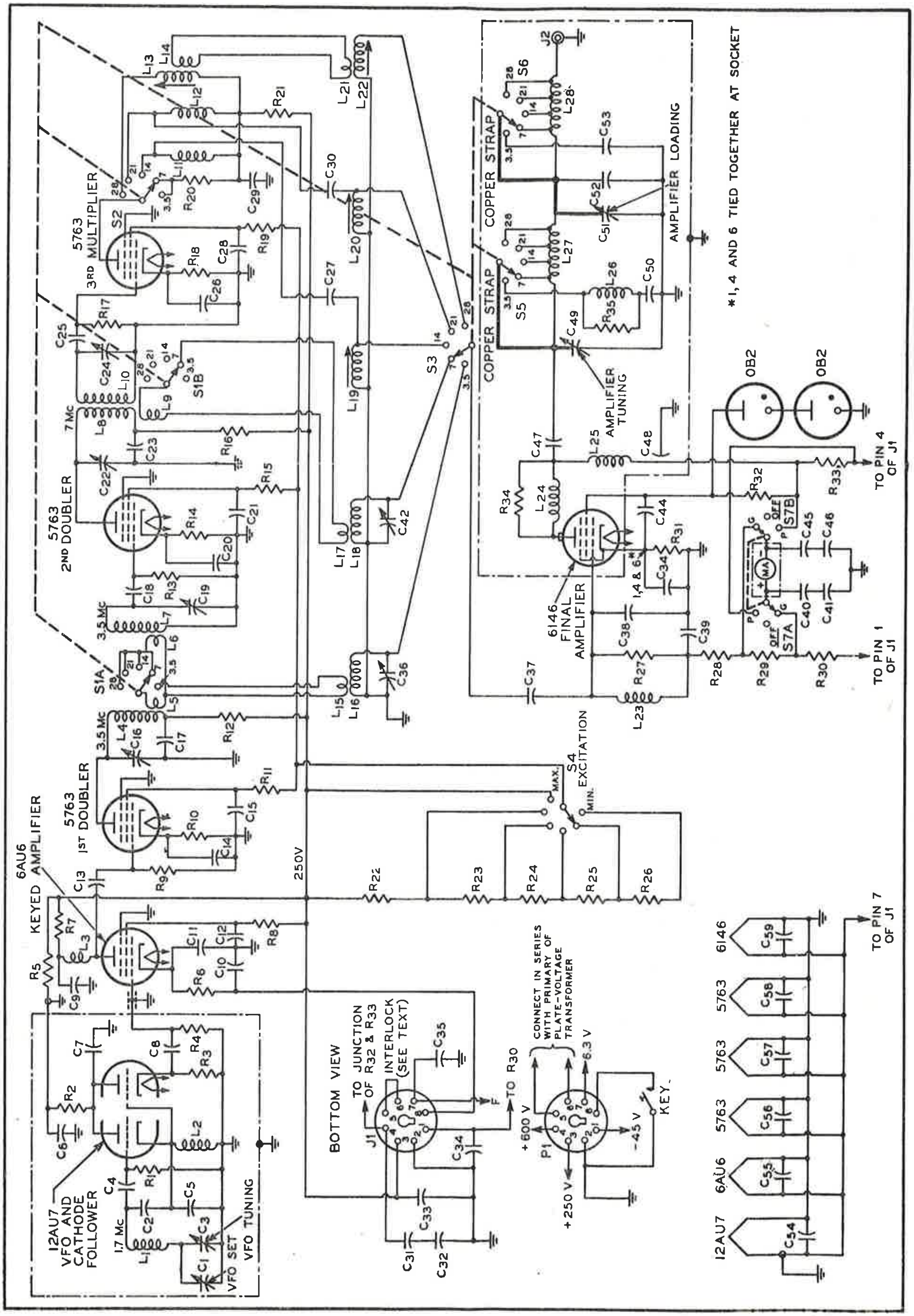
12AU7 VFO AND CATHODE FOLLOWER
VFO SET
VFO TUNING
1.7 Mc
6AU6 KEYED AMPLIFIER
5763 1ST DOUBLER
3.5 Mc
5763 2ND DOUBLER
7 Mc
5763 3RD MULTIPLIER
S1A
S1B
S2
S3
S4 EXCITATION
MAX.
MIN.
250V
6146 FINAL AMPLIFIER
COPPER STRAP
S5
S6
AMPLIFIER TUNING
AMPLIFIER LOADING
J2
0B2
0B2
S7A
S7B
OFF
MA
1, 4 & 6*
TO PIN 4 OF J1
TO PIN 1 OF J1
TO PIN 7 OF J1
BOTTOM VIEW
J1
TO JUNCTION OF R32 & R33
INTERLOCK (SEE TEXT)
TO R30
P1
+600 V
+250 V
-45 V
6.3 V
KEY
CONNECT IN SERIES WITH PRIMARY OF PLATE-VOLTAGE TRANSFORMER
12AU7
6AU6
5763
5763
5763
6146
*1, 4 AND 6 TIED TOGETHER AT SOCKET

Fig. 3 (Opposite page) — Complete schematic diagram of the bandpass transmitter-exciter.

switching is not needed here because this link is used for only one band. Switch S2 in the plate of the multiplier selects the proper output circuit for operation on 14, 21, or 28 Mc.

The unused multipliers are left idling — a small amount of cathode bias is provided to hold the plate current at a safe value. This plate current, which is the same amount that flows when the key is up, is about equal to the operating plate current. Therefore, there is very little change in power-supply drain and no special regulation is demanded of the exciter power supply. The third multiplier, which is unused on 3.5 and 7 Mc, has a small resistor switched into its plate circuit to maintain plate voltage on the valve and to prevent the screen current from becoming excessive. A short circuit could have been used in place of the resistor, but it was felt that high-frequency parasitics might be encountered if a low-inductance plate circuit were used.

Excitation Control

Excitation to the final is controlled by adjustment of the screen voltage of the frequency multipliers. The screen grids of all the multipliers are supplied from a common bus, the voltage of which is controlled by tap switch S4 and series resistors R22, R26. If it were not for the desirability of controlling the excitation to the final, the idle multipliers could be switched off when not in use, thus effecting some saving in the power drain; however, this arrangement would require two more switch sections.

6146 Bias

Grid bias for the 6146 is provided by three different means: cathode bias, a small amount of fixed bias (45 volts), and grid-leak bias. The original design contemplated the use of screen clamping of the final to eliminate the need for fixed bias. However, experience showed the combination method to be better suited to the 6146. Because of the husky cathode in the 6146, screen control is not as effective as in some other tetrodes, and ordinary clamp valves do not reduce the plate current to a safe value when excitation is removed.

Even the use of a VR tube in series with the screen does not suffice where complete plate-current cutoff is desired. There seems to be a small amount of screen emission which allows the screen to assume a slightly positive potential, thus preventing complete cutoff. With the series VR tube and an ordinary clamp arrangement, the unexcited plate current is about 25 ma. Under this condition, the 6146 amplifies the noise generated by the high-gain multipliers and produces an annoying hiss in the receiver.

A small amount of fixed bias, conveniently obtained from a 45-volt battery obviates all this trouble, provided the screen voltage is not allowed to rise above the operating value and change the cutoff characteristic. A pair of miniature voltage-regulator tubes are used to hold the screen voltage at 210 volts when excitation is removed. These tubes may extinguish when excitation is applied and the screen current rises; however, such operation is not objectionable as long as the screen voltage is between 150 and 200 volts — high enough for efficient operation. For phone operation, it is desirable to keep the VR tubes extinguished to prevent shunting of the ac screen voltage. The value of the screen-dropping resistor is chosen to provide approximately 190 volts on the screen under normal operation; this value rises to only 210 volts when the excitation is removed.

The stability of the final amplifier is improved materially by the use of a small mica capacitor connected directly at the socket from grid to ground. This capacitor helps to attenuate the grid harmonics and lessens the tendency towards oscillation by keeping the grid impedance low. A small amount of resistance loading is used across the grid circuit to help flatten the bandpass characteristic and to prevent the 'valley' in the overcoupled-circuit response curve from being too deep.

Pi-Network Tank Circuit

The pi-network tank circuit helps eliminate TVI and is well suited to all-band operation, particularly where bandswitching is desired. The pi network provides considerably more harmonic reduction than the parallel tank circuit without a sacrifice in amplifier efficiency. In regions where the TV signal strength is high, there is no need for additional filtering if reasonable design precautions are taken.

The network chosen for this transmitter was calculated from the curves given by Pappenfus and Klippel.*

The only trouble encountered was the result of the initial assumptions. The plate impedance of the 6146, under normal operating conditions is approximately 2,000 ohms or less — somewhat

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* "Pi Network Tank Circuits," by E. W. Pappenfus, WOSYF, and K. L. Klippel, WOSQO, CQ, Sept. 1950, page 27.

lower than that of most tetrodes. The pi network capacitances required for matching this rather low plate impedance to 50-ohm coaxial line are fairly high if an operating Q of 15 is chosen for the 3.5-Mc band.

The importance of keeping the Q as high as this is rather dubious, particularly because it has never been adequately demonstrated that a high Q contributes materially to the reduction of higher-order harmonics when stray coupling is usually the source of most of the trouble. With a Q of 7, not low enough to reduce the amplifier efficiency, the network becomes more manageable and the values of the capacitances are reasonable. On the higher-frequency bands, the Q may be increased because the required capacitance is less.

L-Network

The complexity of the switching is not materially increased by the addition of an L network[**] between the pi and the antenna. The use of an L network offers two added advantages: (1) further reduction of the capacitance required to make the network fit the design curves; (2) additional harmonic attenuation. The pi network steps the impedance down to about 500 ohms, and the L network reduces it from 500 to 50 ohms. A little cut-and-try is necessary to obtain the proper taps on the inductors and the proper values of loading capacitance for the different bands if a Q meter is not available for measurement of these values beforehand. It is well to note that the values of the loading capacitance given in the charts in the previously mentioned reference are for optimum or full load; the capacitance must be increased somewhat to provide for tuning up and lighter loading.

A certain amount of compromise in the matter of flexibility of adjustment must be accepted in a multiband rig, because the required capacitance values vary greatly when tuning from 3.5 to 28 Mc especially where a single wide-range capacitor is to be employed. However, constants chosen for the tank provide ease of adjustment without unduly complicating the switching. On 3.5 Mc, it is necessary to switch in additional capacitance to provide proper operation without compromising the high-frequency performance.

In a complex multiband tank circuit, the use of parallel capacitances may cause high-frequency resonances and parasitics, and this case was no exception. Also, lead lengths in a bandswitching arrangement sometimes prove vulnerable to high-frequency resonances. During the bench stage of the development work on this transmitter, several rf burns were obtained from the "cold" end of the shunt capacitors before the exact nature of the parasitic resonance was recognized. However, once the parasitic paths were discovered, the judicious use of a grid-dip meter indicated where corrective measures were needed.

Because of its high power sensitivity, the 6146 cannot be expected to be free from parasitics — particularly since its high-frequency performance is so good. It is necessary, therefore, to use a parasitic choke in the plate lead and to load this choke with resistance to keep its Q low at high frequencies.

The shunt tank capacitor, C50, resonating with the main variable tank capacitor on 3.5 Mc, developed a parasitic which was eliminated by the addition of choke L26 to the circuit. The resistance loading (R35) across this small inductance introduces enough high-frequency loss to suppress the parasitic oscillation without affecting the low-frequency performance.

As a TVI precaution, the shunt padding capacitors used for both tuning and loading should be checked to make certain that they do not resonate in any of the TV channels.

PARTS LIST

C1, C22, C24, C25, C42
    50 pf, midget padder.
C2, C5
    0.001 μf, silver mica, 500 volts.
C3 30 pf, variable.
C4, C25, C37, C50,
    100 pf, mica, 500 volts.
C6, C7, C9-C12, C14, C15, C17, C20, C21, C23, C26, C28, C29, C31-C35, C39-C41, C43, C44-C46, C54-C59,
    0.01 μf, disc ceramic, 500 volts.
C8, C13, C18, C27, C30,
    100 pf, ceramic, 500 volts.
C16, C19, C36,
    100 pf, midget padder.
C38 25 pf, silver mica, 500 volts.
C47 0.001 μf, mica, 2500 volts wkg.
C48 0.001 μf, 1000 volts.
C49 100 pf, variable, 0.03″ spacing.
C51 300 pf, variable, 0.024″ spacing.
C52 150 pf, mica, 500 volts.
C53 470 pf, mica, 500 volts.

J1 8-pin octal plug.
J2 Coaxial connector.

L1 80 turns No. 24 enam., 1.½″ dia., 2.½″ long. (see text).

[**] "Further Notes on Pi & L Networks," by E. W. Pappenfus, W0SYF, and K. L. Klippel, W0SQO, CQ, May 1951, page 50.

L2, L3, L11, L12,	RFC, 0.5 mh.
L4	40 turns No. 24 enam., 1″ dia. form.
L5	3 turns No. 22 enam., link, on same form. as L4.
L6	3 turns No. 22 enam., link, on same form. as L7.
L7	32 turns No. 24 enam., 1″ dia. form.
L8	18 turns No. 22 enam., 1″ dia. form.
L9	2 turns No. 22 sc enam., link, on same form. as L8.
L10	22 turns No. 22 enam., 1″ dia. from., mtd. on 1.⅜″ centres from L8.
L13	14 turns No. 22 enam., ¾″ long, ½″ dia. form. with adj. ferrite core.
L14	1 turn No. 18, link, mtd. over L13 (see text, Part 2, "Construction")
L15	3 turns No. 22 enam., link, on same form as L16.
L16	30 turns No. 24 enam., 1″ dia. form.
L17	3 turns No. 22 enam., link, on same form as L18.
L18	14 turns No. 22 enam., 1″ dia. form.
L19	16 turns No. 22 enam., ¾″ long, ½″ dia. form. with adj. ferrite core.
L20	10 turns No. 22 enam., ⅝″ long, ½″ dia. form. with adj. ferrite core.
L21	1 turn No. 18, link, mtd. over L22 (see text, Part 2, "Construction")
L22	8 turns No. 22 enam., ¾″ long, ½″ dia. form. with adj. ferrite core.
L23, L25,	RFC, 2.5 mh.
L24	7 turns No. 24 enam. wound on R34.
L26	7 turns No. 24 enam. wound on R35.
L27	19½ turns No. 16, 2″ dia., 2″ long, tapped at 6, 13, 16 and 17 turns.
L28	17 turns No. 20, 1″ dia., 1″ long, tapped at 4, 10, 13 and 16 turns.
MA	Meter, 0-1 ma fsd.
R1, R9, R17,	56K ohms.
R2, R7, R12, R16, R20, R21,	1,000 ohms.
R3	2,200 ohms.
R4	100K ohms.
R5	47K ohms, 1 watt.
R6	220 ohms.
R8	39K ohms.
R10, R14, R18,	330 ohms.
R11, R15, R19, R22,	15K ohms, 1 watt.
R13, R24,	27K ohms.
R23	18K ohms, 1 watt.
R25	33K ohms.
R26	220K ohms.
R27	22K ohms, 1 watt.
R28	8.2K ohms.
R29	Meter shunt, see text, Part 2, "Construction."
R30	560 ohms.
R31	100 ohms, 5 watts.
R32	30K ohms, 10 watts.
R33	Meter shunt, see text, Part 2, "Construction."
R34	22 ohms.
R35	33 ohms.

All resistors ½ watt unless specified otherwise.

(With acknowledgements to RCA)

(TO BE CONCLUDED)

VOLTAGE STABILISERS

When a low-power dc supply is required, with a stable output voltage, three alternatives are available:

1. Storage batteries and accumulators.
2. A well filtered rectified ac supply.
3. One or more voltage stabilisers fed from a conventional rectified ac supply.

The latter method has many advantages, e.g.:

(a) The output voltage remains sensibly constant with changes in load or fluctuations in supply.
(b) The voltage stabiliser and its associated circuit behave as a low impedance source of voltage.
(c) The circuitry is simple, and the whole unit may be very compact.
(d) By using two or more voltage stabilisers in series across the supply, various voltages may be tapped off, without increasing the total loading, and without affecting the regulation of the output.

Mode of Operation

The voltage stabiliser is a gas-filled, cold cathode tube, designed to utilise fundamental properties of electric current flow in gases at pressures below atmospheric. When a voltage is applied across the electrodes in such a tube the free electrons always present in the gas are accelerated. When these electrons attain sufficient energy to produce more electrons by collision with gas molecules, the gas is ionised and the impedance of the tube falls suddenly. If a suitable resistor is included in series with the tube, the voltage across the tube falls to a characteristic level which remains sensibly constant over a wide range of current variation. The series resistor also contributes to the stability of the output voltage.

When the gas is ionised a glow is seen inside the electrode structure, the colour of the glow depending on the nature of the gas filling. This glow is always on the surface of the cathode, and the area of cathode covered with glow is an

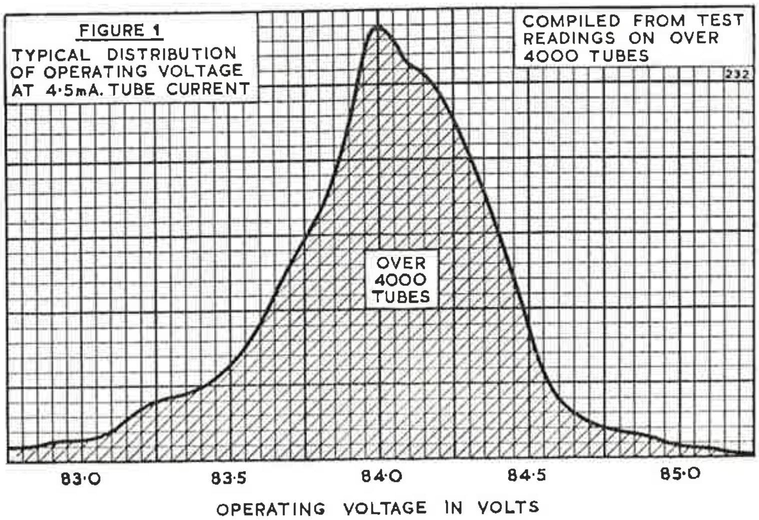


FIGURE 1

TYPICAL DISTRIBUTION OF OPERATING VOLTAGE AT 4·5mA. TUBE CURRENT

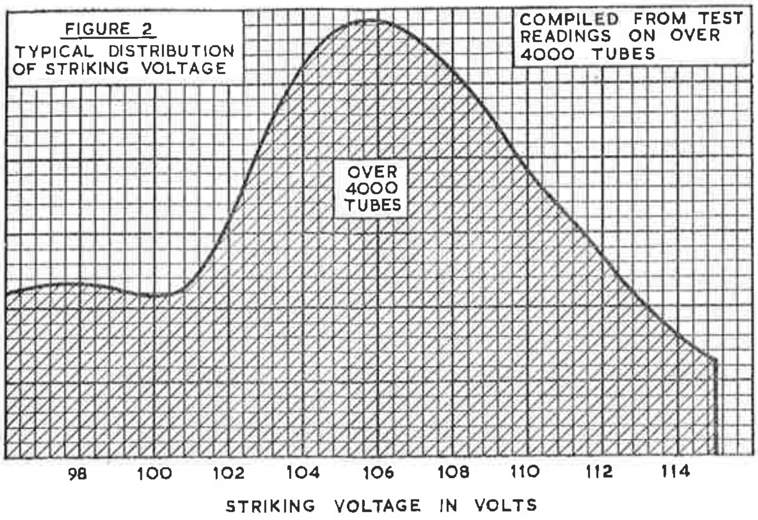


FIGURE 2
TYPICAL DISTRIBUTION OF STRIKING VOLTAGE

indication of the current passing. Voltage stabilisers normally operate in the region of normal fall of cathode potential, i.e. the cathode is not completely covered with glow, and in that region the operating voltage is almost independent of the current flowing through the tube. If the current rises and the regulating properties are lost. Too the cathode with glow, the tube is said to be operating in the region of abnormal fall of cathode potential, and at once the impedance rises and the regulating properites are lost. Too low a current causes instability and possibly extinction. Voltage stabilisers should, therefore, be operated within the current limits specified.

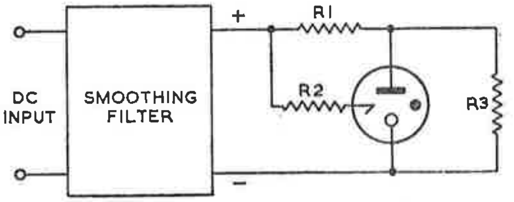


Fig. 3

Operating or Output Voltage

The operating or output voltage of a voltage stabiliser (sometimes called the maintaining or gap voltage) is dependent on the nature of the cathode surface and the composition of the gas filling. With any particular tube design differences occur in operating voltage from tube to tube and for this reason this voltage is generally quoted in the data as approximate. Typical production distribution diagrams are shown in Fig. 1 and 2.

For any individual tube, however, the operating voltage remains extremely constant throughout life and, furthermore, repeatability after successive switching is of a very high order as may be seen from the data sheets of such tubes as the 5651/QS1209.

Tubes with Ignition Electrodes

In some tubes an ignition electrode is provided which may be regarded as an auxiliary anode and which must be connected to the main HT via a high value resistor R2 (see Fig. 3). Before the tube strikes, the potential of the ignition electrode is that of the supply whilst the potential of the main anode is necessarily lower and is decided by the voltage divider formed by R1 and R3. In the interests of stability a high value of series resistor R1 is desirable, but in the absence of an auxiliary ignition electrode a limit is reached when the anode potential approaches the striking voltage. With an ignition electrode the main anode can

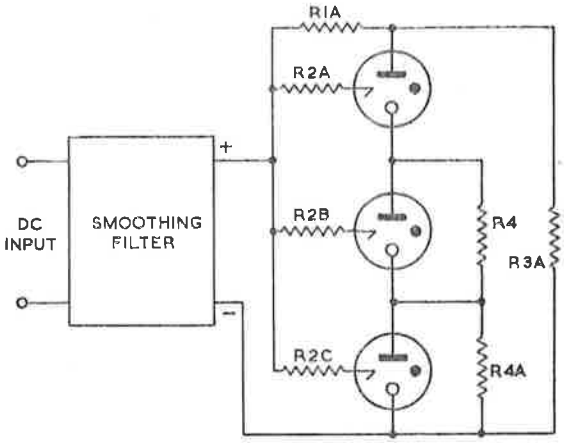


Fig. 4

take over even when its own potential is only slightly in excess of the operating voltage, thus permitting the use of a high value of series resistor. The current in the auxiliary circuit is generally less than 0.5ma.

Tubes in Series

Stabilisers may be used in series (see Fig. 4) to provide voltages exceeding those of a single tube. To ensure striking of each tube it is necessary to connect the ignition electrodes through individual high value resistors R2, R2A, R2B etc., to the HT positive and also to connect the intermediate cathode-anode junctions, through resistors R4, R4A etc., to the HT negative. Tubes of different voltages may be used in combination in this way, within their ratings, care being taken to ensure that the sum of the load and tube currents at any point from which output voltage is taken does not exceed the maximum cathode current of the tubes through which these currents pass.

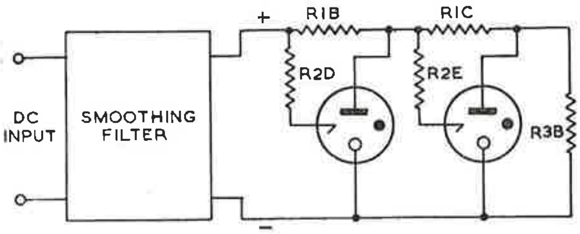


Fig. 5

Tubes in Cascade

Stabilisers may be used in cascade (see Fig. 5) to obtain still greater reduction of output voltage fluctuations than is obtainable with one tube, and also in a combination of series and cascode connection.

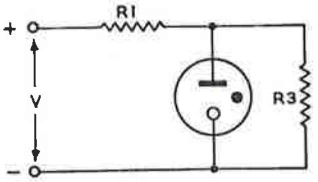


Fig. 6

Basic Circuit

The general case may be considered as follows (see Fig. 6):

Let V = Applied dc voltage
R_1 = Anode series resistor
R_3 = Load resistor
V_S = Striking voltage of tube
V_O = Operating voltage of tube
IT = Current through tube after ignition
IL_1 = Current through load before tube ignites
IL_2 = Current through load after tube ignites

The instant V is applied, $R_1 + R_3$ is the only load, the tube not having ignited. Thus there will be a drop across R_1 of $(R_1.IL_1)$ volts. This drop must not be so high as to prevent the voltage across the tube from being equal to or greater than V_S.

Thus we have $V-(IL_1.R_1) > V_S$ .... (1)

$$V_O = IL_1\ (R_1+R_3) \quad (3)$$
$$V\text{-}V_O = R_1\ (IT+IL_2) \quad (4)$$
$$V = R_3.IL_2 \quad (2)$$

From the above we have the following relationships:

$$IL_1.R_3 > V_S \quad \ldots\ldots\ldots\ldots (5)$$
$$V = IL_2\ (R_1 + R_3) + R_1.IT \quad \ldots\ldots (6)$$
$$IL_1 - IL_2 = \frac{R_1}{R_1 + R_3}.IT \quad \ldots\ldots\ldots\ldots (7)$$

In general V_O, V_S, R_3, IL_2 and IT are known, and thus the remaining values may be calculated.

(With acknowledgements to EEV)

7163

PHOTOCONDUCTIVE CELL

The 7163 is a small, sturdy, head-on type of cadmium-sulphide photoconductive cell designed for use in street lighting control and in a variety of industrial light-operated relay applications. It features extremely high illumination sensitivity permitting direct relay operation in most applications without the use of an amplifier.

The spectral response of the 7163 covers the approximate range from 3300 to 7400 angstroms, as shown in the accompanying spectral response curve. The maximum response occurs at about 5800 angstroms. The 7163 therefore, has its highest sensitivity to yellow-red light. The photosensitive surface in the 7163 is cadmium sulphide located between metal strips.

The 7163 utilizes a metal envelope with a glass window and two-pin base. It is hermetically sealed to permit operation under conditions of high humidity.

DATA

General:

Spectral Response	S—15
Wavelength of Maximum Response	5800 ± 500 angstroms
Sensitive Surface, inc. met. strips:	
Shape	Rectangular
Length (min)	0.65 in.
Width (min)	0.54 in.
Area (min)	0.35 sq. in.
Maximum Overall Length	0.90 in.
Greatest Diameter	1.24 ± 0.02 in.
Seated Length	0.28 ± 0.06 in.
Maximum Axial Distance from external surface of window to sensitive surface	0.15 in.
Base	JETEC E2-47
Operating Position	Any
Weight (app)	0.4 oz.

Maximum Ratings, Absolute Values:

Voltage between Terminals (dc or peak ac)	250 volts
Power Dissipation:	
Sensitive surface fully illuminated	0.3 watt
Sensitive surface partially illuminated	0.85 w/sq. in.
Photocurrent	50 ma
Ambient Temperature Range	—75 to + 60°C

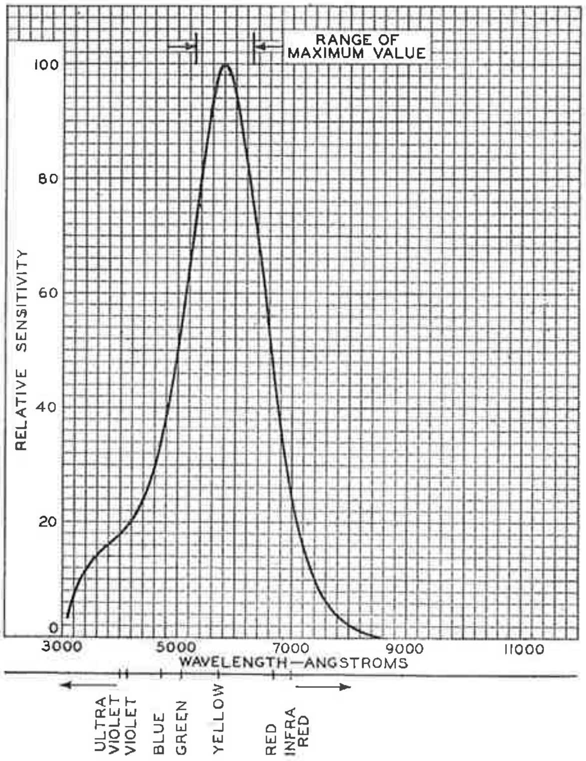


Fig. 1 — Spectral Sensitivity Characteristic for Equal Values of Radiant Flux at all Wavelengths.

Characteristics:

Under conditions with an ac voltage (rms) of 50 volts between terminals and at an ambient temperature of 25°C.

	Min	Median	Max	
Sensitivity:				
Radiant*, at 5800 angstroms	—	290	—	μa/μw
Luminous† at 0 cps	—	0.082	—	a/lumen
Illumination†, at 0 cps	1	2	3	ma/fc
Photocurrent‡	—	—	40	μa
Fall Characteristic		See Graph		
Rise Characteristic		See Graph		

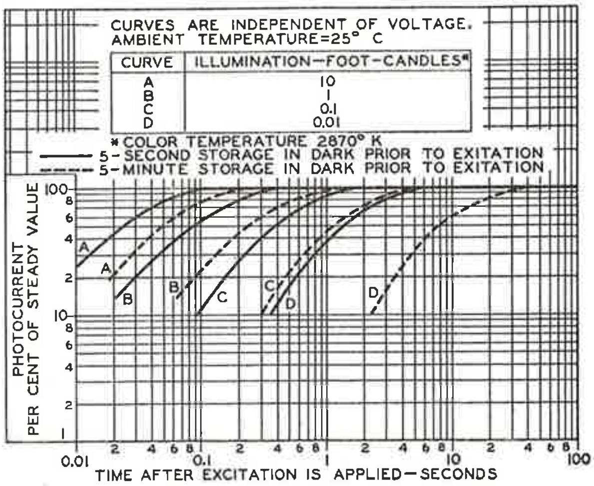


Fig. 2 — Typical Rise Characteristics of Type 7163.

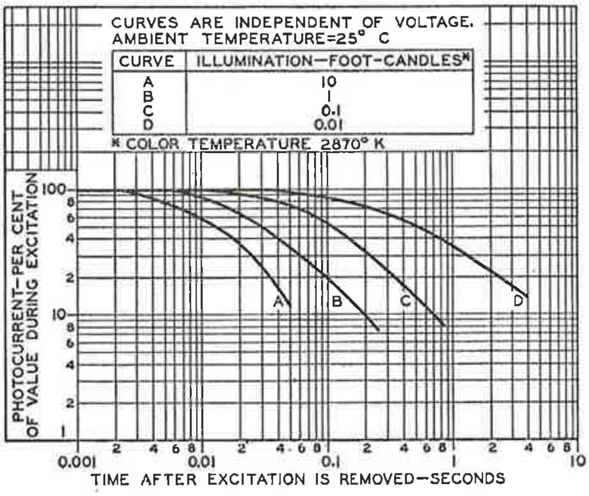


Fig. 3 — Typical Fall Characteristics of Type 7163.

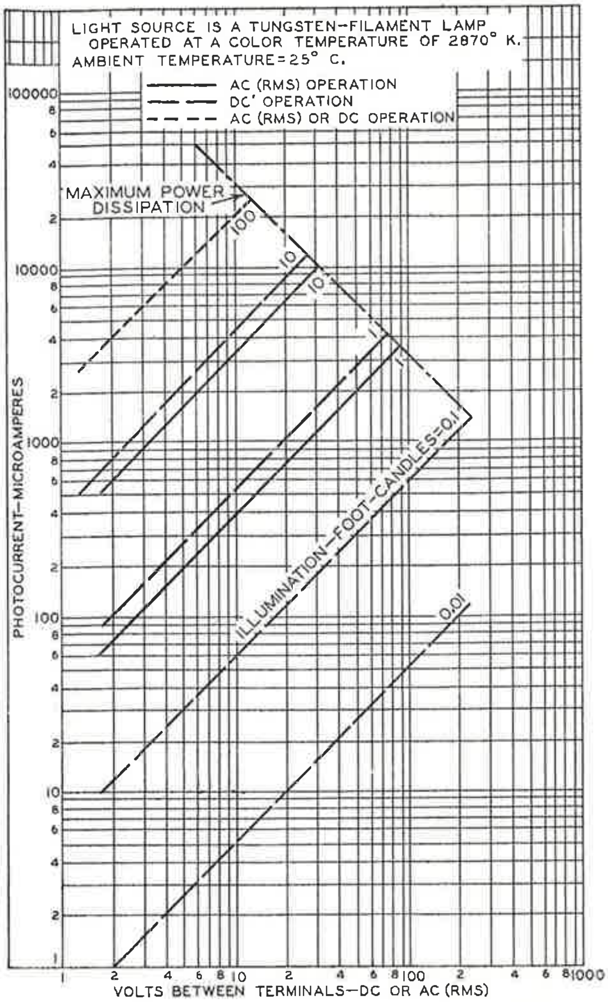


Fig. 4 — Average Characteristics of Type 7163.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength at constant electrode voltages.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Illumination Sensitivity. The quotient of output current by the incident illumination, at constant electrode voltages.

---

* For conditions where the incident power is 6.9 microwatts.

† For conditions where light flux from a tungsten-filament lamp operated at 2870°K is transmitted through a filter (Corning No. 5900 having an effective transmission of luminous flux of 12.5 %) onto the sensitive surface. The value of illumination incident on the sensitive surface is 8 foot-candles measured before positioning the filter between the lamp and the cell.

‡ Measured approximately 10 seconds after removal of incident-illumination level as established by the filter detailed in the preceding note.

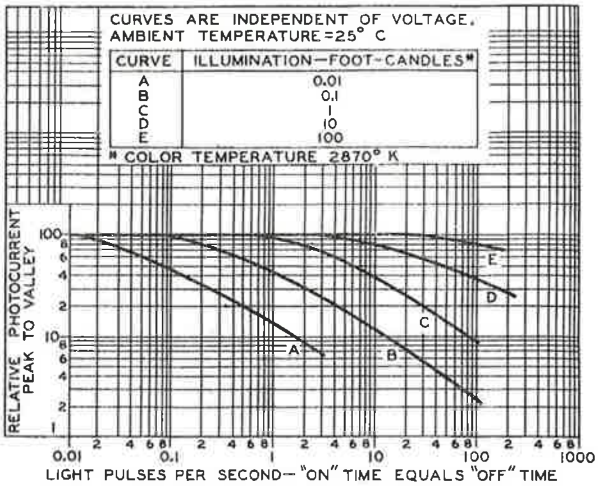


Fig. 5 — Response Characteristics of Type 7163 to Pulsed Light.

OPERATING CONSIDERATIONS

The maximum ratings in the tabulated data are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. In order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply voltage variation, load variation, or manufacturing variation in the equipment itself.

Electrical connections may be made to the base pins of the 7163 by soldering directly to the pins. Soldering of connections to the pins may be made close to the pin seals provided care is taken to conduct excessive heat away from the pin seal; otherwise the heat of the soldering operation will crack the glass seals of the pins and damage the cell. Connection can also be made to the base pins by means of insulated clips.

The voltage between terminals of the 7163 may be applied without regard to polarity.

The incident illumination should cover an area at least 0.1 inch in diameter.

Exposure of the 7163 to radiation so intense as to cause excessive heating of the cell may permanently damage it.

The rise time for the photocurrent to reach a steady value after excitation is applied to the cell is a function of the illumination, as shown in the accompanying diagrams. For greatest stability, final circuit adjustments should not be made for at least ten minutes after application of excitation.

Photocurrent decay after the removal of excitation is a function of time and of the illumination during excitation, as shown in the accompanying diagrams.

Typical circuits for the 7163 are shown. In each of these circuits the relay is normally energised when light is incident on the cell; when the light is interrupted or the light level drops to a predetermined value, the relay operates. The potentiometer in each of the circuits is employed to adjust the value of photocurrent at which the relay operates. Each circuit operates with light levels as low as one foot-candle.

The response of the 7163 to pulsed light and the effect of ambient temperature are shown in the accompanying diagrams.

The angle of view of the 7163 may be narrowed by the use of a hood of the desired length placed

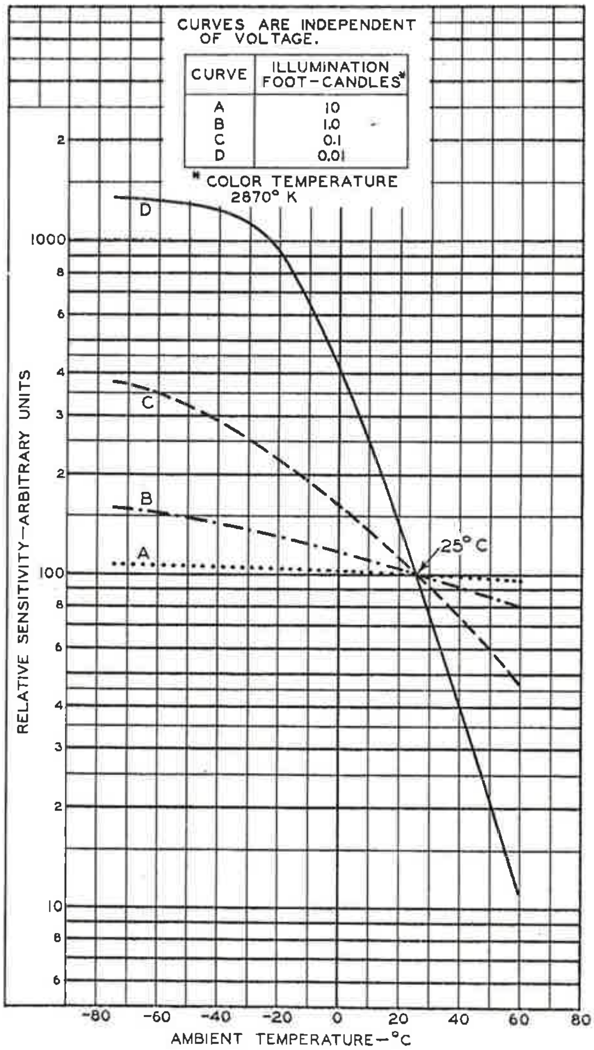


Fig. 6 — Typical Characteristics of Type 7163.

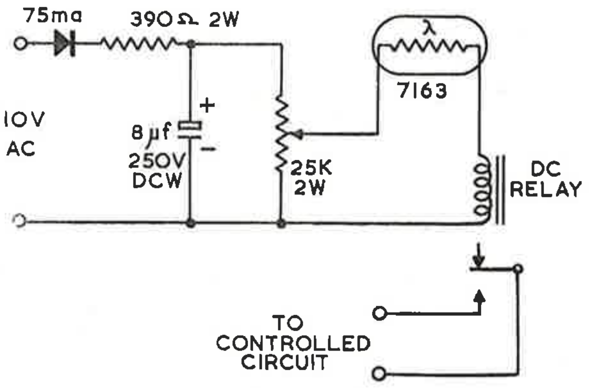
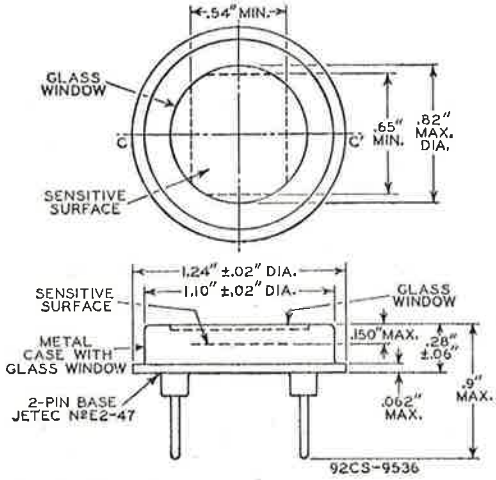


Fig. 7 — Typical High-Sensitivity Circuit for the 7163.

in front of the cell. In some applications where the light source is several feet from the cell, a simple lens used to collimate the light beam will serve to utilize the available amount of light most effectively.

DIMENSIONAL OUTLINE



PLANE THROUGH MINOR AXIS (CC') OF SENSITIVE SURFACE AND THE CELL AXIS MAY VARY FROM PLANE THROUGH CELL AXIS AND THE TWO PINS BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE CELL AXIS) OF ± 10°

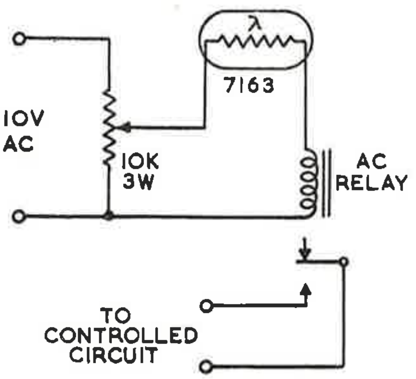
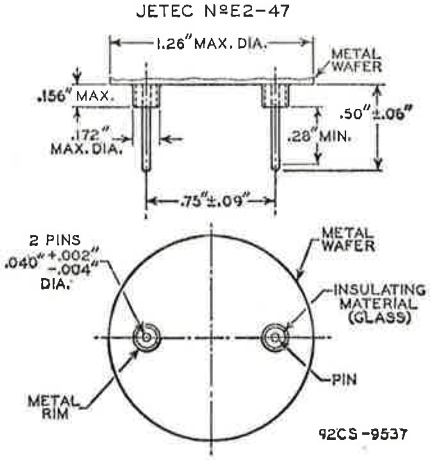


Fig. 8 — Typical "On-off" Control Circuit for the 7163.

For a given illumination, the output current will have its highest value when the incident illumination is normal (at an angle of 90°) to the face of the cell. For smaller angles of incidence, the output current decreases. The decrease depends upon several factors, including the angle of incidence of the illumination, the amount of illumination, and the area of sensitive surface illuminated.

BASE DRAWING



NEW RELEASES

2N706, 2N706A

These units are p-n-p Mesa-type silicon transistors for use in high-speed switching service. They are similar to the 2N1300 and 2N1301 but offer improved high-speed performance. They are designed to meet the stringent environmental and mechanical requirements of military specifications. The 2N706 features a short storage time of 60 microseconds maximum at a collector current of 10 ma, a typical gain — bandwidth product of 400 Mc, the high minimum beta of 20, with a 1 watt dissipation at 20°C. The 2N706A is similar but with a storage time of only 25 microseconds at a collector current of 10 ma.

2N1169, 2N1170

The 2N1169 and 2N1170 are two new bi-directional, composite-emitter-collector-type transistors in the JEDEC TO-5 package for medium-speed switching applications. These germanium alloy-junction transistors are particularly useful in bidirectional switching, core-driver, and ac-signal relay circuits of industrial and military data-processing systems. In these new transistors, the emitter and collector can be used interchangeably, permitting either electrode to be used as the input or output electrode. This unique feature makes these transistors particularly desirable in memory devices, because in such devices, a single transistor of this type can be used for transmission of current in either one or the other direction. The switching of current from one direction to the other is accomplished without appreciable loss in current gain and makes possible considerable simplification in circuit design.

2N1683

The 2N1683 is a germanium p-n-p diffused-junction Mesa transistor specifically designed for high-speed switching applications in commercial and military data-processing equipment. This transistor is particularly useful in pulse-amplifier, inverter, flip-flop, and logic-gate circuits. The 2N1683 features (1) a rugged Mesa structure performance at high frequencies, (2) high power with an extremely small base width to insure top dissipation capability; (3) high current transfer ratio, (4) high breakdown-voltage and punch-through-voltage ratings, (5) fast switching because of large gain-bandwidth product and low-total stored charge in saturation-type switching circuits, and (6) a typical gain-bandwidth product of 80 Mc which makes this type especially useful in electronic computers operating at pulse repetition rates up to 10 Mc.

6FA7

The 6FA7 is a new diode with sharp cutoff twin-plate tetrode of the 9-pin miniature type. This valve is particularly useful in frequency-divider and complex-wave generator circuits of electronic musical instruments. The diode unit and the tetrode unit utilize a single cathode. The twin plates of the tetrode unit are on opposite sides of the cathode. This arrangement minimizes interaction between the electron streams from the cathode to each plate. Each tetrode plate has a maximum dissipation rating of 1.5 watts.

2041

The 2041 is a sturdy, liquid-cooled beam power valve intended for use in long-range search radar and in pulsed transmission for communication service as a plate-pulsed rf power amplifier. Full ratings may be applied at frequencies from 174 to 600 Mc, and is useful at higher frequencies. With a duty factor of 0.06 and a pulse duration of 200 microseconds, the 2041 can provide a useful peak power output of 180 kilowatts at 450 Kc; with dtuy factor of 0.01 and pulse duration of 2000 microseconds, it can provide a useful peak power output of 300 kilowatts at 450 Mc.

4021

The 4021 is a new travelling-wave tube incorporating periodic-permanent-magnet focusing. The 4021 is an intermediate-power amplifier tube intended for use in L-band microwave systems. It can deliver 1 watt of cw power throughout the frequency range of 1000 to 2000 Mc. The typical gain at 1 watt is 37 db in this range. Variants of this prototype to satisfy particular equipment requirements can be supplied.

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THE SUPPRESSION OF VOLTAGE SURGES IN SEMICONDUCTOR RECTIFIER EQUIPMENT

Introduction

Silicon and germanium rectifiers are capable of extremely reliable service provided their ratings, especially their voltage ratings, are not exceeded during operation. The purpose of this note is to examine in some detail one type of voltage surge which can be produced by the transformer in an equipment and which has, in fact, occasionally been the cause of rectifier failure in service. This voltage transient occurs when the transformer is switched off under "no load" conditions or under loaded conditions with a choke input filter, and is produced by the sudden decay of magnetic flux in the transformer core. This is rather an elusive transient to observe in practice, as its magnitude depends upon the instant in the cycle at which "switch off" takes place.

It is of particular importance to guard against this type of transient, as, with the increasing miniaturisation of power supplies made possible by the use of silicon and germanium rectifiers, it has become the practice to drive transformers to higher flux densities, with a result that this transient becomes more difficult to suppress. It may, in fact, prove to be more economical in space in a particular design to limit the maximum flux density to which the transformer is driven, in order that the capacitor required to suppress the switch-off surge should not become excessively large. It may prove difficult in an application to effect a satisfactory compromise in this respect.

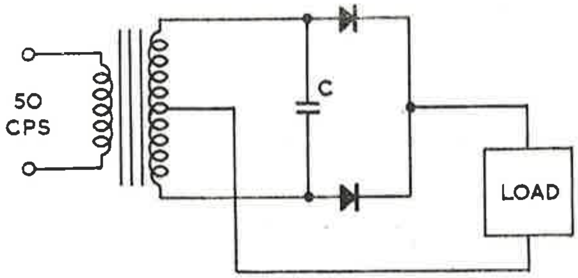

Fig. 1

Area of Core in^2	B_{max} (Kilogauss)	No-load current in primary (C = O) (ma)	Largest value of surge observed for various values of C (volts)					
			0.1μf	0.5μf	1μf	2μf	4μf	8μf
1.34	7.6	75	380	200	150	100	—	—
1.1	9.3	145	600	400	250	150	—	—
0.915	11.1	325	>600	530	300	250	150	100
0.73	14	650	>600	>600	350	280	210	150

Fig. 2

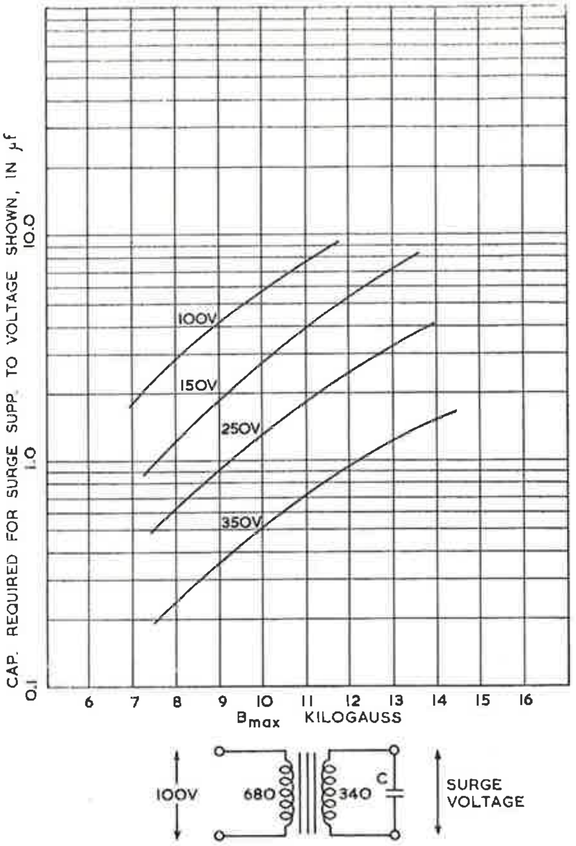

Fig. 3 — Variation of Required Capacitance with B_{max} for a Constant Turns-per-volt Ratio. (Supply Frequency 50 cps, B_{max} X Section Area Constant, Turns-per-volt 6.8).

It was with a view to giving assistance in this aspect of equipment design that one particular transformer was examined in some detail and the size of capacitor required to obtain various degrees of surge reduction was measured.

Experimental Results

It is easy to see by simple theoretical reasoning that, for a particular transformer, size reduction by increasing the maximum flux density (B_{max}) in the core will result in increasing the magnitude of the switch-off transient. The energy stored in the core is proportional to $(B_{max})^2$ and the volume of the core (V). If the area of the core, and consequently V is reduced, for the same primary voltage B_{max} will increase so that B_{max} xV remains constant. It follows that the energy stored in the core will be directly proportional to B_{max}. The result of increasing B_{max} will be to increase the energy available in the transient by a proportional amount.

The transformer examined had a centre-tapped secondary consisting of 170 + 170 turns of No. 17 SWG and a primary of 680 turns of No. 22 SWG. The core consisted of Sankey No. 28A, T and U laced, silicon steel "Stalloy" No. 107, 0.014 inch laminations. The measurements were made with a supply frequency of 50 cps. The primary voltage was held constant at 100 volts. The size of the voltage transients obtained across the secondary winding on switching off was measured with a long persistence oscilloscope for various values of the surge limiting capacitor (C) shown in Fig. 1, under "no-load" condition.

The core area, and consequently B_{max}, was varied by changing the thickness of the stack of laminations. This is approximately analogous to what would happen in practice, namely a stack of laminations of smaller overall dimensions would be selected, in order to take full advantage of the decrease in core area.

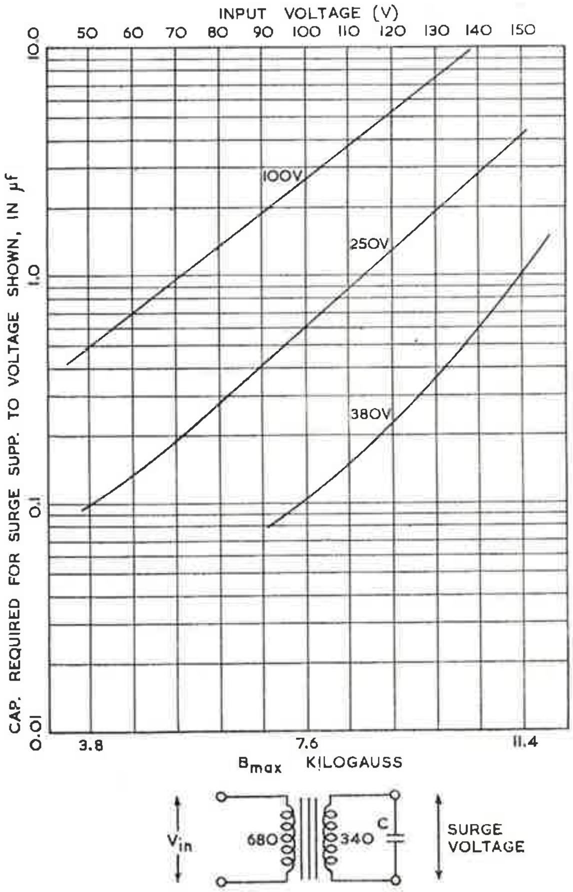

Fig. 4 — Variation of Required Capacitance with B_{max} for Constant Core Section Area. (Supply Frequency 50 cps, Core Area 1.35 Square Inches).

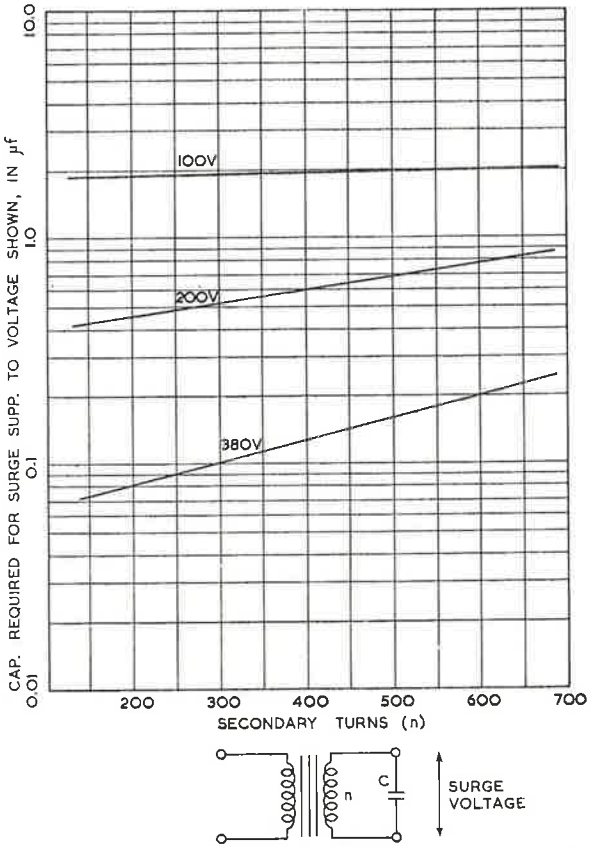

Fig. 5 — Variation of Required Capacitance with Secondary Turns for Constant B_{max} (Supply Frequency 50 cps, B_{max} Constant at 7.6 Kilogauss, Core Area 1.35 Square Inches).

The results obtained are shown in the table Fig. 2. With $C = 0$ the surge voltage was >600 volts in every case. The duration of the surge was several milliseconds.

It can be seen from the table that halving the volume of the transformer core resulted in roughly an eightfold increase in size of the capacitor needed to obtain the same degree of surge suppression. The results are shown graphically in Fig. 3.

Results obtained by increasing the maximum flux density for a constant core area are shown in Fig. 4. The value of capacitance required for a given degree of surge suppression increases very rapidly with flux density.

In Fig. 5 the variation of required capacitance is shown with variation of the number of turns in the secondary. This curve was obtained with constant B_{max}. The value of capacitance increases with increase in the number of turns.

By judicious extrapolation of these curves, it is possible to estimate the size of capacitor required for a core area of up to about 2 square inches. For core areas greater than this the suppression of this type of surge will require rather large values of capacitance. Under these conditions it may be found advisable to use a "dummy load," so that "no load" conditions are never experienced.

(With acknowledgements to G.E.C., Application Report, No. 17.)

(For further information on the use of semiconductor rectifiers, see "Radiotronics" Vol. 24 No. 9, "Silicon Power Rectifiers," and Vol. 24 No. 10, "Installation and Cooling of Silicon Rectifiers").

Will You Be Disappointed?

Subscription Renewal Memos are now being mailed to subscribers in Australia and New Zealand. Last year several subscribers who did not renew in time were not able to obtain the full set of 1960 issues. The responsibility is YOURS. Please return the pink card with your remittance so as to reach this office by December 2nd. Only in this way can you ensure continuity, as stocks of this magazine are usually exhausted within 2-3 months of publication.

BOOK REVIEWS

"Understanding Radio," H. M. Watson, H. E. Welch, G. S. Eby, McGraw-Hill Book Co. Inc. Size 9" x 6". 716 pages, 522 figures. Second Edition.

This book is intended for students who have little or no background in electricity, science or mathematics. It is aimed at those who are interested in radio more as a vocation or hobby than for engineering and technical college students.

The text and drawings have been prepared with this in mind. Even the normal terminology of radio is introduced only gradually through the book so as not to confuse the reader. The practical side of the art is not forgotten, and there are many simple circuits and layouts in the building and operation of which the reader can prove and cement the knowledge offered in the text.

A strong accent is placed on the "whys" of radio, so that the student is lead to a proper understanding of the matter rather than being faced with a number of propositions which he is just required to accept.

"Practical Transistor Servicing," W. C. Caldwell, Howard W. Sams & Co. Inc. Size 8½" x 5½". 191 pages, 105 diagrams.

The serviceman's problem is one of diagnosis. As the author of this book points out, anyone can change parts, and the serviceman's problem is over once he has found the fault. The serviceman brings two indispensable qualities to his workbench, his technical knowledge and his past experience.

Experience of course is a matter of time, whilst many men argue that they have little opportunity for study. The growth of transistorized equipment is forcing the man who doesn't want to be left behind to familiarize himself with transistors, their peculiar problems, and the diagnostic techniques to use with them. This volume fills a real need in this direction.

The information packed into this book is quite astonishing, and the method of presentation practical and straight to the point. Thus, readers are spared long discussions on holes and electrons, and are shown how to do the job, using a wealth of practical field experience.

NEW RELEASES

(Continued from page 245)

4401

The 4401 is a new image orthicon camera tube intended for use in colour cameras, and is supplied in matched sets of three tubes. The tubes in each set are matched for uniformity of sensitivity over the scanned area and for uniformity of background. In addition, these tubes are selected so that an exceptionally high sensitivity tube is included for use in the blue channel which normally receives the least amount of light. The 4401 is interchangeable with types 5820, 6474, and 7513.

6264-A

The 6264-A is a medium-mu pencil triode for military and critical industrial applications. This A-version retains the desirable characteristics of its prototype and, in addition, is designed to meet special tests for low-pressure break-down, low- and 1-hour stability life performance. The 6264-A has an amplification factor of 40 and is intended for use particularly as a frequency multiplier, but is also useful as an rf power amplifier and oscillator. The 6264-A can be operated with full ratings at frequencies up to 500 Mc, and with reduced ratings at frequencies as high as 1700 Mc. It can be operated at altitudes up to 60,000 feet without pressurization.

7262A; 7735

The 7735 is a new 1-inch vidicon which utilizes a recently-developed photo-sensitive surface of extremely high sensitivity and uniformity which promises improved performance in industrial and other closed-circuit TV applications. The 7735 is capable of producing pictures of satisfactory quality with as little as 0.1 foot-candle illumination on the faceplate. Still another feature of this new tube is the increased voltage ratings which permit substantial increases in both the amplitude response and the limiting resolution capability — from 600 TV lines to approximately 900 TV lines. The 7735 is designed for conventional TV camera equipment. Its shorter companion tube, the 7262-A, has an overall length of approximately 5-1/8 inches, and is designed especially for compact, transistorized TV cameras.

6CW4

HIGH-MU NUVISTOR TRIODE

The 6CW4 is a high-mu triode of the nuvistor type intended for use as a grounded-cathode, neutralized rf-amplifier valve in vhf tuners of television and FM receivers. The 6CW4, in this application, provides exceptional performance in fringe areas and other locations where signal levels are extremely weak. This nuvistor triode features excellent signal power gain and a noise factor 2 to 4 db better than valves currently in use in television receivers.

The high-gain and low-noise capabilities of the 6CW4 are achieved by very high transconductance and excellent transconductance-to-plate-current ratio (12500 micromhos at a plate current of 8 milliamperes and a plate voltage of 70 volts).

The 6CW4 nuvistor triode offers additional advantages because of its unique design: extreme reliability, exceptional uniformity of characteristics from valve to valve obtained by the use of parts made to extremely close tolerances and precise electrode spacings; very small size; and low heater-power and plate-power requirements. All metal-and-ceramic construction insures ruggedness and long-term stability.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:

Voltage (ac or dc)	6.3 ± 10%	volts
Current at 6.3 volts	0.13	amp

Direct Interelectrode Capacitances (Approx.):

Grid to plate	0.92	pf
Grid to cathode, heater and shell	4.1	pf
Plate to cathode, heater and shell	1.7	pf
Plate to cathode	0.18	pf
Heater to cathode	1.3	pf

Characteristics, Class A1 Amplifier:

Plate Supply Voltage	110	volts
Grid Supply Voltage	0	volts
Cathode Resistor	130	ohms
Amplification Factor	62	
Plate Resistance (Approx.)	6300	ohms
Transconductance	9800	μmhos
Plate Current	7.6	ma
Grid Voltage for plate current =10 μa (Approx.)	−4	volts

Mechanical:

Operating Position	Any
Maximum Over-all Length	0.8″
Maximum Seated Height	0.625″
Maximum Diameter	0.440″
Envelope	Metal Shell
Base	Medium Ceramic-Wafer Twelvar 5-Pin (JEDEC No. E5. 65)
Socket	Cinch Mfg. Corp. No. 133 65 10 001, or Equivalent

Maximum Ratings, Design-Maximum Values:*

Plate Supply Voltage†	300	volts
Plate Voltage	125	volts

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* For definition of this rating system, see Operating Considerations. For further information, see "Radiotronics" Vol. 24, No. 5, "The Design-Maximum Rating System."

† A plate supply voltage of 300 volts may be used provided that a sufficiently large resistor is used in the plate circuit to limit the plate dissipation to one watt under any condition of operation.

Grid Voltage:		
Negative-bias value	55	volts
Peak positive value	0	volts
Plate Dissipation	1	watt
Cathode Current	15	ma
Peak Heater-Cathode voltage:		
Heater negative with respect to cathode	100	volts
Heater positive with respect to cathode	100	volts

Typical Operation:

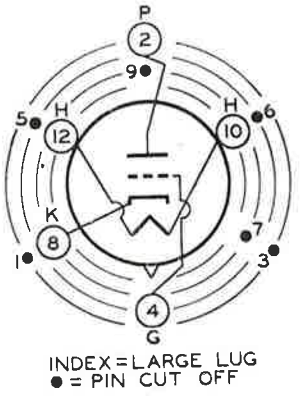
Plate Voltage	70	volts
Grid Supply Voltage	0	volts
Grid Resistor	47000	ohms
Amplification Factor	68	
Plate Resistance (Approx.)	5440	ohms
Transconductance	12500	μmhos
Plate Current	8	ma

Maximum Circuit Values:

Grid-Circuit Resistance:‡		
For fixed-bias operation	0.5	megohm
For cathode-bias operation	2.2	megohm

BASING DIAGRAM

(Bottom View)



Pin 1: IC	Pin 7: IC
Pin 2: Plate	Pin 8: Cathode
Pin 3: IC	Pin 9: IC
Pin 4: Grid	Pin 10: Heater
Pin 5: IC	Pin 11: Omitted
Pin 6: IC	Pin 12: Heater

Where an internal connection (IC) is noted, the pin is cut off close to the ceramic wafer. The corresponding socket connections must not be used.

OPERATING CONSIDERATIONS

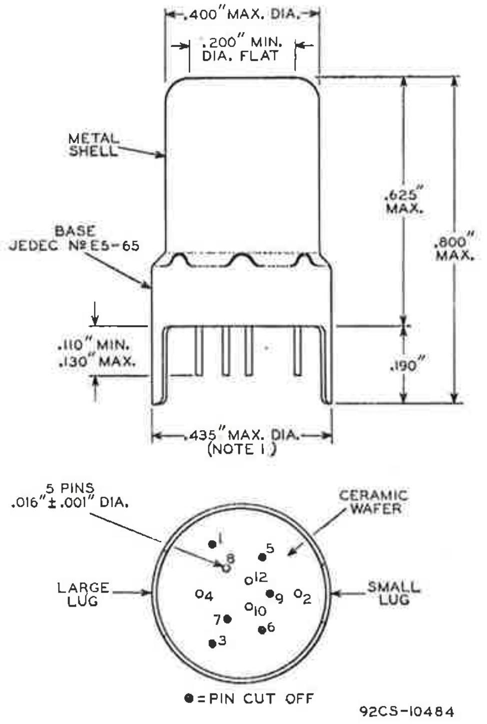
The maximum ratings in the tabulated data are established in accordance with the following definition of the Design-Maximum Rating System for rating electron valves.

Design-Maximum ratings are limited values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no design-maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

DIMENSIONAL OUTLINE



NOTE 1: MAXIMUM O.D. OF 0.440" IS PERMITTED ALONG 0.190" LUG LENGTH.

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‡ For operation at metal-shell temperatures up to 125°C.

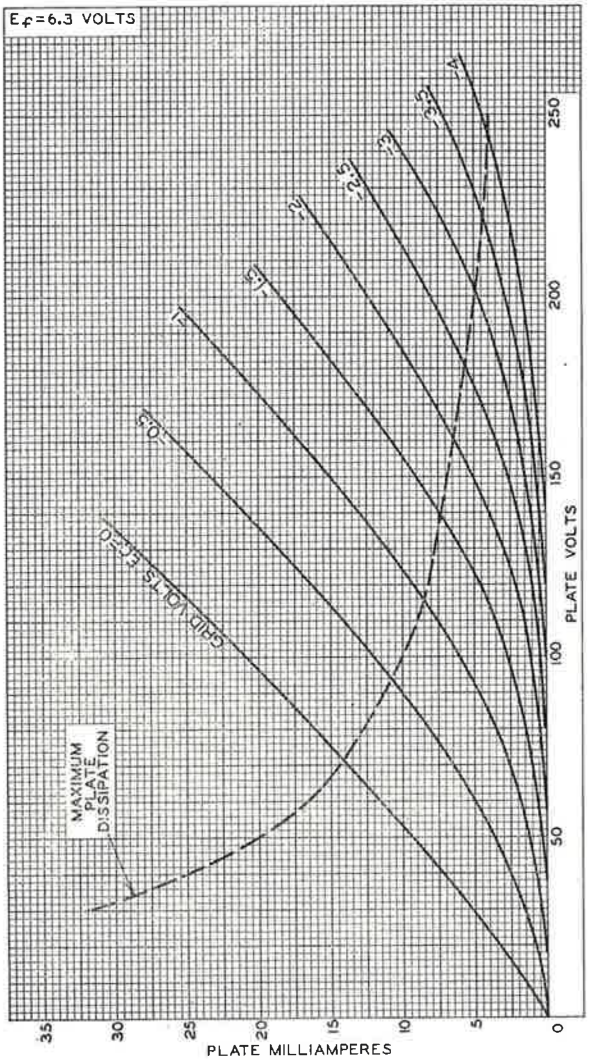

Fig. 1 — Average Plate Characteristics for Type 6CW4.

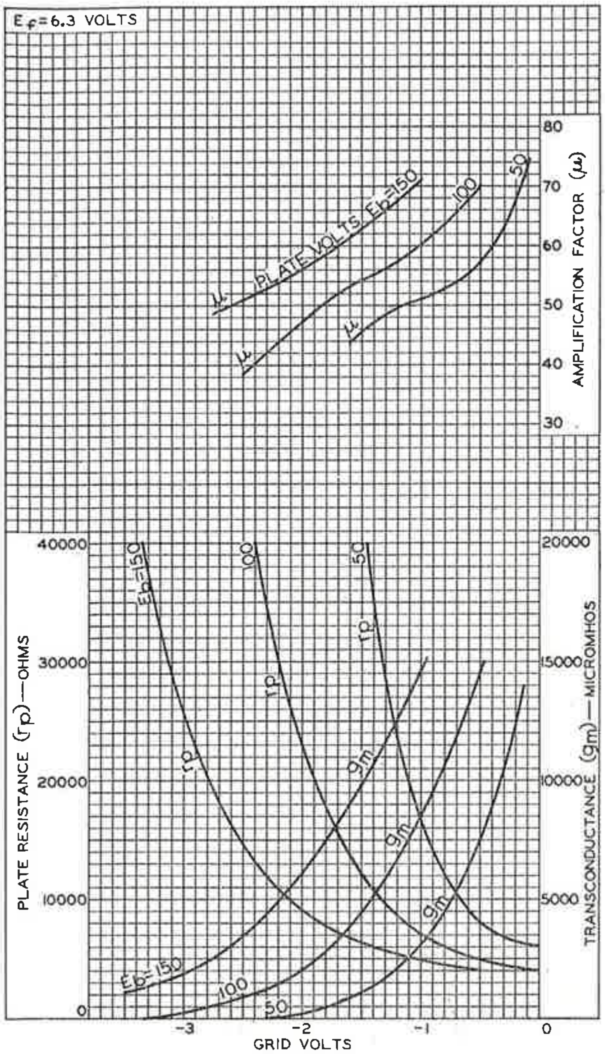

Fig. 2 — Average Characteristics for Type 6CW4.


AWV