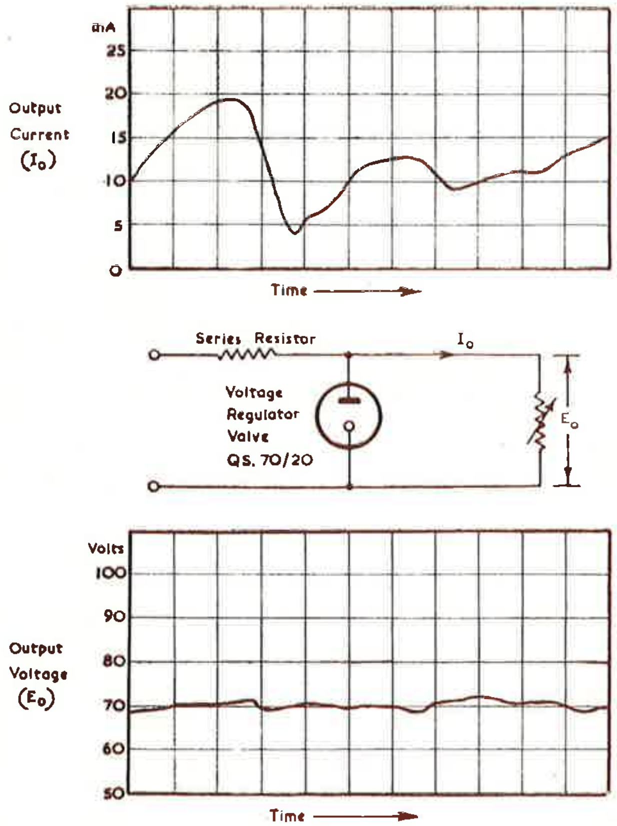
Radiotronics

AN A.W.V. TECHNICAL PUBLICATION DEVOTED TO RADIOTRONS AND THEIR APPLICATION

Number 141

February 1950



A voltage regulator valve such as the QS. 70/20 provides an effective means of supplying a constant voltage to a varying load. (Page 18.)

CONTENTS

●

RESEARCH • DESIGN • MANUFACTURE

NUMBER 141 FEBRUARY 1950

RADIOTRONICS

A Radiotron technical release published in Sydney, N.S.W.,
by Amalgamated Wireless Valve Company Pty. Ltd.

Technical Editor
F. Langford-Smith, B.Sc., B.E.,
Senior Member I.R.E. (U.S.A.).

Asst. Tech. Editor
Ian C. Hansen, Member I.R.E. (U.S.A.).

Sub-Editor
R. Ainsworth, A.S.T.C., A.M.I.R.E. (Aust.).

CONTENTS

[Radiotronics for 1950 will be dated as follows: No. 141, February; No. 142, April; No. 143, June; No. 144, August; No. 145, October; No. 146, December.]

All communications should be directed in Australia to—
Amalgamated Wireless Valve Co. Pty. Ltd.
(Sales Promotion Department)
47 York Street, Sydney

in New Zealand to—
Amalgamated Wireless (Australasia) Ltd., P.O. Box 830, Wellington, C1, N.Z.

Radiotronics is published six times a year, and the subscription for the year 1950 is 5/-.

Wholly set up and printed by
Cloister Press (D. & W. Short), Redfern, N.S.W.

The Elements of a TV System*

A Brief Review of the Functions of the Most Important Parts of the U.S.A. TV System, With An Explanation of the Reasoning Behind the Choice of Standards, Types of Transmission, Shape of Synchronizing Pulse, Etc.

by JOHN H. ROE

Supervisor, TV Systems Engineering Group Engineering Products Department

Introduction

The boom in television has created a need for trained operators which is far in excess of the available facilities for training them. As a result, many stations face the start of regular operating schedules with a staff of inexperienced (in TV, that is) operators who, although they have been briefed in their duties, have only a beginner's knowledge of the overall TV system.

No amount of written description can provide the background which several months of operating experience can give, nor can a story of the system, complete in every detail, be set down in a few pages. However, it is felt that a recapitulation of some of the basic philosophy of the television system will be helpful to many of the beginners in the business, and may prove an incentive to further reading. Therefore an effort will be made to review briefly the functions of some of the important parts of the system and explain the thinking behind them. Detailed discussion of circuits and methods is purposely omitted in order to devote the space to an overall picture of the system. References to other papers covering much of such detail are given in a bibliography.

Limitations

No true appreciation of any system can be realized without some understanding of its basic limitations, and a discussion of the television system should therefore begin by reviewing these. The most serious limitation of a television system, as in the case of an aural system, is "noise." The same phenomena that cause hum, crackle, and hiss in the background of a sound broadcast, cause bar-like shadows, random blotches, and "snow storms" in the background of a television picture. The word, noise, has been carried over from aural terminology into television terminology with the same connotation. In other words, any spurious elements in a television picture are generally called noise. In reading the following discussions, it will be helpful to remember that much of the reasoning behind the methods used in the television system is based on the need to minimize the effects of noise.

Spurious noise components in the signal arise from two general sources, (a) shot noise and thermal agitation in valves and other circuit elements, and (b) pickup from associated or remote electrical apparatus. The best means for minimizing noise is to maintain a high signal-to-noise ratio in all parts of the system, but where this is impossible, special circuits are a distinct aid in extending the useful range of operation.

Noise limits, among other things, the ability of the system to resolve fine detail. However, a more direct limitation on the resolving power of the system is the frequency bandwidth available in the transmission system. This limitation has commercial aspects of more significance than the technical aspects because of the limited room available in the radio spectrum. As a result, the decisions of the Federal Communications Commission effectively determine the limits of resolution within the noise-free service area of any station. Through long years of field testing it has been found that a six-megacycle channel will provide adequate resolution and at the same time will yield a reasonable number of channels.

Other factors which limit overall performance are the fineness of scanning apertures,* the degree of accuracy with which tonal gradations are reproduced, and the brightness range of which the reproducing device is capable. However, if it can be assumed that the transmission system between the pickup and reproducing devices is reasonably linear, then the problems arising from these particular limitations are confined largely to the pickup and reproducing devices themselves, and do not affect system considerations to the same extent as limitations described

---

* Reprinted from RCA Broadcast News by courtesy of the Radio Corporation of America.

* The use of the word *aperture* in television probably arose from the use of scanning discs where the light passed through small holes which traversed the projected area of the scene. Small holes traversing closely spaced lines in the area were capable of greater resolution than larger holes traversing more widely spaced lines. Though scanning discs are no longer used, the term aperture is still applied to the scanning device in a general sense. In electronic television, the diameter of the "aperture" is simply the diameter of the scanning beam of electrons in the plane of the scanned image. Similarly the term *aperture correction* is applied to means (usually the use of special circuits) for compensating the picture signal for loss of resolution caused by finite size of the beam and by non-uniform distribution of electrons over the cross-sectional area of the beam.

in the preceding paragraphs, and as certain economic factors do.

Economic factors usually limit the degree to which technological development is used to improve the quality of performance. Methods may be known by which some of the physical limitations of the system can be overcome, but sometimes such methods are not used for a long time after their discovery because means for applying them economically are not developed simultaneously. In other words, their use increases the cost of equipment excessively. This is especially true in the case of receiving equipment which must be produced in large quantities at low unit cost. Such methods often do find their way into transmitting equipment where low unit cost is not so important and where quality of performance is paramount. Quality is stressed in transmitting equipment to provide reliability and to reduce the need for including in the receivers complicated and expensive corrective circuits. Examples are circuits for automatic correction of scanning linearity, and clamp circuits for accurate re-establishment of black level, or d.c. restoration, as it is often called.

Standards

During the decade preceding the entrance of the United States into World War II, Radio Corporation of America carried on an extensive programme of research and development in television and the information so derived has been largely responsible for the formulation of the standards governing our present black-and-white system. The earliest work on standards was done through the medium of the Radio Manufacturers' Association. Much more extensive work on standards was carried on later by the National Television System Committee and the Radio Technical Planning Board, the former body being set up to deal exclusively with television standardizing problems and to bring about agreement among the several interested groups on suitable standards for recommendation to the FCC. With the approach of commercial broadcast service, the FCC adopted the recommendations of these bodies as the basis for tentative standards of good operating practice. Activity of the RMA has continued on television and its recommendations have been extended to cover much of the detail of studio and transmitter operation, and of receiver design. While a considerable portion of this material still exists only in the form of recommendations to the FCC, it will undoubtedly constitute the major part of the final standards.

One of the most important standards recommended is the one which describes the wave shape of the picture signal. This standard is outlined in detail in a drawing which is reproduced in Fig. 5. Reference will be made to this drawing from time to time in discussing the system, and an attempt will be made to clarify the reasoning involved in establishing many of the specifications included in it.

Scanning system

The standard system of scanning in television is one in which the scene or image is traversed by the aperture in lines which are essentially horizontal, from left to right and progressively from top to bottom. The aim is to have the aperture move at constant velocity both horizontally and vertically during actual scanning periods because that is a simple type of motion to duplicate in the reproducing aperture and because it provides a uniform light source in the reproducer. At the end of each line the aperture, or scanning beam, moves back to the start of the next line very rapidly. The time occupied by doing this is called the *fly-back* or *retrace* period. In a similar way, the beam moves from the bottom back to the top after the end of each picture scan. Motion during retrace periods need not be linear. The complete traversal of the scene is repeated at a rate high enough to avoid the sensation of flicker. This rate has been set at 60 times per second because most of the power systems in the United States are 60 cycle systems, and synchronization with the power system minimizes the effects of hum and simplifies the problem of synchronizing rotating machinery in the television studio (film projectors) with the scanning.

It has appeared rather recently that the choice of 60 cycles for the vertical scanning frequency was a fortunate one for another reason. The progress of the art has included means for obtaining brightness levels in the reproduced pictures which are appreciably greater than those used in motion picture theatres. It is well known that the threshold of flicker increases as the brightness increases. Thus, 48 or 50 cycle flicker would be noticeable to some observers at modern brightness levels in television receivers. Persistence of vision varies in different people and those whose persistence characteristics are very short are conscious of the 60-cycle flicker in the bright pictures on some present-day receivers. Therefore it appears that a still higher vertical frequency would be desirable if other factors would permit. Needless to say, the interline flicker, mentioned later in connection with interlacing is also less objectionable with the higher scanning rate.

Another important factor affecting flicker is the persistence characteristic of the screen material in the receiver. This can be made long enough to overcome any appearance of flicker even with scanning rates less than 50 cycles per second, but, if carried too far, such long persistence causes ghost-like trailing after moving objects in the scene. Judicious choice of screen persistence is a great aid in reducing flicker.

Obviously the scanning apertures in the pickup and reproducing parts of the system must be in exact synchronism with each other at every instant. To accomplish this, synchronizing information is provided in the form of electrical pulses in the retrace intervals between successive lines and between successive pictures. The retrace intervals are useless in reproducing picture information, hence are kept as short as circuit considerations permit, but are useful places in which to insert the synchronizing pulses. These pulses are generated at the studio in the same equipment that controls the timing of the scanning of the pickup tube, and they become part of the complete composite signal which is radiated to the receiver. Thus scanning operations in both ends of the system are always in step with each other. Synchronizing is discussed in more detail in a later section.

The number of scanning lines is the principal factor determining the ability of the system to resolve fine detail in the vertical direction. The number of scanning lines is also related to the resolving power in the horizontal direction because it is desirable to have the same resolution in both directions. Thus, as the number of lines increases, the bandwidth of the system must also increase to accommodate the greater resolution required in the horizontal direction. The present system employs 525 lines, a number arrived at after thorough consideration of the related questions of channel width and resolution by the N.T.S.C. and the R.T.P.B.

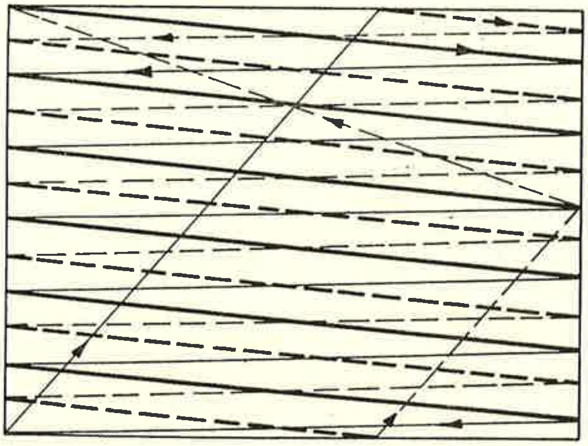


FIG. 1. Odd-line interlaced scanning system with 13 lines. Consecutive fields are indicated by solid and dotted lines, respectively.

One of the most interesting features of the television scanning system is the interlacing of the scanning lines, a scheme which is used to conserve bandwidth without sacrificing freedom from flicker. The sensation of flicker in a television image is related to the frequency of the illumination of the entire scene. It has no relation to the number of scanning lines nor to the frequency of the lines themselves. Therefore a system which causes the entire area of the scene to be illuminated at a higher frequency, even though the same lines are not scanned during successive cycles of illumination, results in greater freedom from flicker. Interlacing does just this by scanning part of the lines, uniformly distributed over the entire picture area, during one vertical scan, and the remaining part or parts during succeeding scans. Thus, without changing the velocity of the scanning beam in the horizontal direction, it is possible to obtain the effect of increased frequency of picture illumination.

In the standard two-to-one interlaced system, alternate lines are scanned consecutively from top to bottom after which the remaining lines, that fall in between those included in the first operation, are likewise scanned consecutively from top to bottom. (See Figs. 1 and 2 which illustrate the principle.) In the 525-line system, each of these groups, called a *field*, consists of $262\frac{1}{2}$ lines. Two consecutive fields constitute a *frame* or complete picture of 525 lines. Each field is completed in 1/60 of a second and each pair of fields, or frame, in 1/30 of a second. The effect on the observer's eye, from the standpoint of flicker, is that of repetition of screen illumination every 1/60 of a second, yet the complete picture is spread out over 1/30 of a second.

The important result of interlacing is a reduction in the bandwidth of the frequencies generated in the picture signal, for a given value of limiting resolution, as compared to the bandwidth produced in a system using sequential scanning. This may be understood as follows: In either system, interlaced or sequential, the vertical scanning frequency must be the same and must be high enough to avoid the sensation of flicker. In the standard television system this frequency is 60 cycles per second. In a sequential system, *all* of the scanning lines must be traversed in the basic vertical scanning period. However, in the two-to-one interlaced system, only *half* of the scanning lines are traversed in the same period. Thus, obviously, the horizontal velocity of motion of the aperture in the interlaced system is only half of the velocity in the sequential system, and likewise the signal frequencies are reduced by the same factor.

Interlaced scanning has certain inherent faults among which are interline flicker, and horizontal break-up when objects in the scene move in the horizontal direction.

Interline flicker results from the fact adjacent scanning lines are separated in time by 1/60 of a second, and that each line is repeated only at intervals of 1/30 of a second. It is apparent in any part of a scene where some detail of the scene is largely reproduced by a few adjacent scanning lines, and where the contrast in the detail is high. For example, the top edge of a wall which is oriented in the scene so as to be nearly parallel to the scanning lines might be reproduced by only two or three adjacent lines. The 30 cycle flickering of the line segments forming the edge of the wall would be quite noticeable. In the limiting condition, where the wall is exactly parallel to the scanning lines, the edge would be reproduced by only one line repeated at intervals of 1/30 of a second. This is probably the worst possible condition, but one which is encountered rather infrequently. The top and bottom edges of the raster nearly always produce objectionable interline flicker because they are nearly parallel to the scanning lines. Interline flicker, like any other type of flicker, is most objectionable in scenes where the high lights are very bright and the contrast is high. When the brightness and contrast are low, interline flicker becomes negligible.

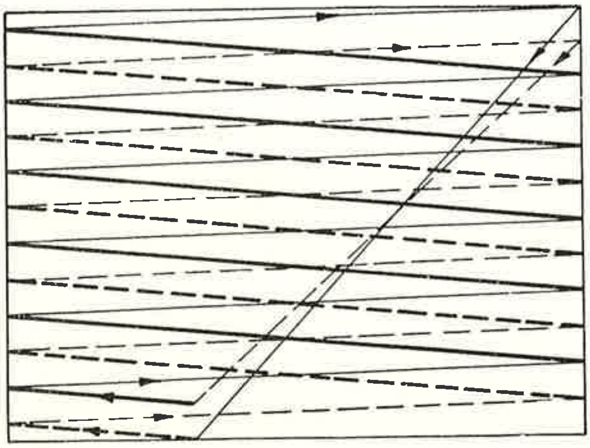


FIG. 2. Even-line interlaced scanning system with 12 lines. Consecutive fields are indicated by solid and dotted lines, respectively.

Break-up exists when an object in the scene moves in the horizontal direction rapidly enough so that the total motion in 1/60 of a second is equal to one or more picture elements. Then vertical edges of the object become jagged lines instead of smooth lines and there is apparent loss in horizontal resolution. This is roughly illustrated in Fig. 3 where two rectangles are shown, the upper one being stationary, and the lower one moving toward the right. The moving rectangle is shown as though it started moving from a position directly below the other. In the moving rectangle, signal is generated, *in both fields*, from the starting position of the left edge because of the storage of information in the pickup tube during the interval between fields. Thus the storage effect causes actual blurring of the trailing edge of a moving object. This is illustrated by the thin extensions of the scanning lines in the second field at the left side. The leading edge of the moving object may have a more definite jagged appearance because the storage effect in the pickup tube cannot fill in the spaces. In non-storage pickup devices, both edges will appear jagged.

The geometrical distortion, illustrated by the tendency for the moving rectangle to become rhombic, is characteristic of any scanning system, whether interlaced or sequential.

Further consideration makes it clear that higher ratios of interlacing would produce these troubles in aggravated form which would be intolerable. Another objection to higher ratios of interlacing is an illusion of crawling of the scanning lines either up or down, depending on motion of the observer's eyes. The effect is extremely annoying and tends to distract the observer's attention from the scene.

The type of interlacing adopted for commercial television is known as *odd-line* interlacing. The total number of lines is an odd integer. Thus the number of lines in each of two equal fields is a whole number plus a half. In this system, the use of perfectly uniform vertical scanning periods (equal to half the product of the total number of lines and the period of one line) and constant vertical scanning amplitude, results in consecutive fields which are displaced in space with respect to each other by half a line, thus producing interlacing of the lines, as illustrated by the 13-line system in Fig. 1. Specifically, as stated above, the total number of lines in the standard system is 525; the number per field is $262\frac{1}{2}$; the vertical scanning frequency is 60 cycles per second; the number of complete pictures (frames) per second is 30; and the horizontal scanning frequency is $60 \times 262\frac{1}{2}$, or 15,750 cycles per second.

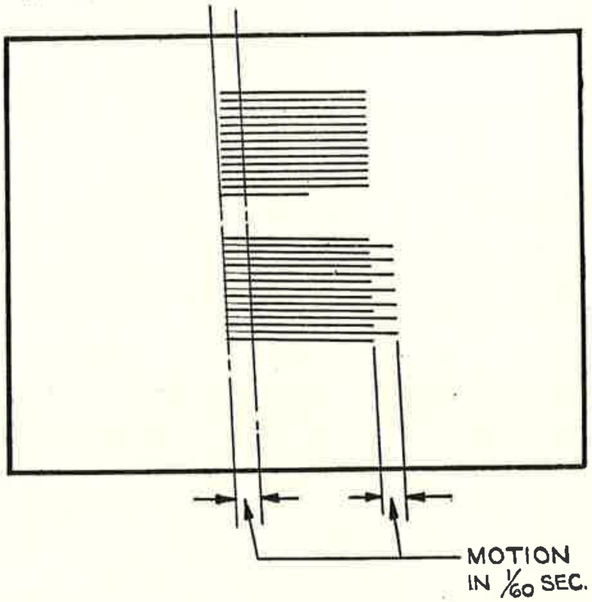


FIG. 3. Effect of horizontal motion of vertical edges in 2-to-1 interlaced system. Upper object stationary. Lower object moving to right.

Interlacing may also be obtained when the total number of lines is an *even* number, but *even-line* interlacing requires that alternate fields be displaced vertically one half line with respect to each other by the addition of a 30-cycle component to the amplitude of the vertical scanning sawtooth wave (see Fig. 2). This frame frequency component must have a degree of accuracy that is impractical either to attain or maintain. Hence even-line interlacing is not used for commercial television.

One other factor has influenced the choice of the particular number of scanning lines. This is the need for an exact integral relationship between horizontal and vertical scanning frequencies. It has been the practice to attain this relationship by using a series of electronic counting circuits. To secure a high degree of stability, the characteristic count of each circuit was limited to a small integer less than ten, Thus the h/v frequency ratio was required to be related to the combined product of several small integers. In the RCA synchronizing generator equipment, for example, there are four such circuits counting the numbers 7, 5, 5, and 3 respectively. The combined product of these four numbers is 525, the number of lines per frame. The product of 525 and 60 is 31,500 which is the frequency of the master oscillator in the sync. generator. To obtain the correct frequency for the horizontal scanning system, another counter circuit divides the master oscillator frequency by two to yield the required frequency of 15,750 cycles.

Synthesis of the picture signal

The basic part of the signal applied to the reproducer is the series of waves and pulses generated during the actual scanning line periods in the pickup or camera tube. No matter what else is done in the equipment intervening between the two ends of the system, this basic part of the signal should be preserved in character with the greatest possible accuracy. However, during the retrace periods, the pickup tube may generate signals which are spurious or which at least do not contain valuable picture information. Furthermore, retrace lines in the reproducing tube itself, especially during vertical retrace, detract from the picture. It is therefore desirable to include in the picture signal, components which will eliminate spurious signals during retrace and the retrace lines themselves in the reproducer. These results may be obtained by adding synthetically some pulses known as blanking pulses.

Blanking pulses are applied to the scanning beams in both the camera tube and the kinescope in the receiver. *Camera blanking* pulses are used only in the pickup device and never appear directly in the final signal radiated to the receiver. They serve to close the scanning aperture in the camera tube during retrace periods. In orthicon tubes, the picture signal during retrace thus goes to reference black or to some level constantly related to reference black. This is a useful result to be discussed later. In iconoscopes, no such constant relationship to black exists during retrace, and the only function of camera blanking is to prevent spurious discharge of the mosaic during the retrace periods.

Kinescope blanking or *picture blanking* pulses are somewhat wider than corresponding camera blanking pulses. They become integral parts of the signal radiated to the receiver.

The function of the kinescope blanking pulses is to suppress the scanning beam in the kinescope (reproducing tube), or in other words, to close the aperture in the receiver during the retrace periods, both horizontal and vertical. They are simple rectangular pulses having time duration slightly longer than the actual retrace periods in order to trim up the edges of the picture and eliminate any ragged appearance. They are produced in the sync generator from the same basic timing circuits that generate the scanning signals; hence they are accurately synchronized with the retrace periods. Typical wave shapes of a basic camera signal and blanking pulses are illustrated in Figs. 4, A and B respectively. Only parts of two scanning line periods are shown, and the pulse in B is therefore a single *horizontal blanking pulse*. The result of adding the signals in A and B is shown in C where it may be seen that the unwanted spurious part of the camera signal has been pushed downward out of the territory of the basic picture signal. This unwanted part may now be clipped off and discarded leaving the signal illustrated in D.

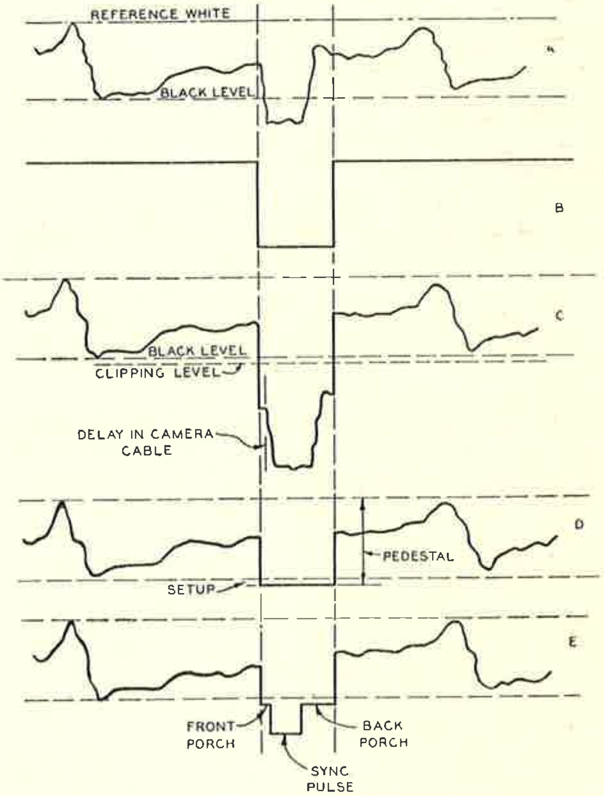
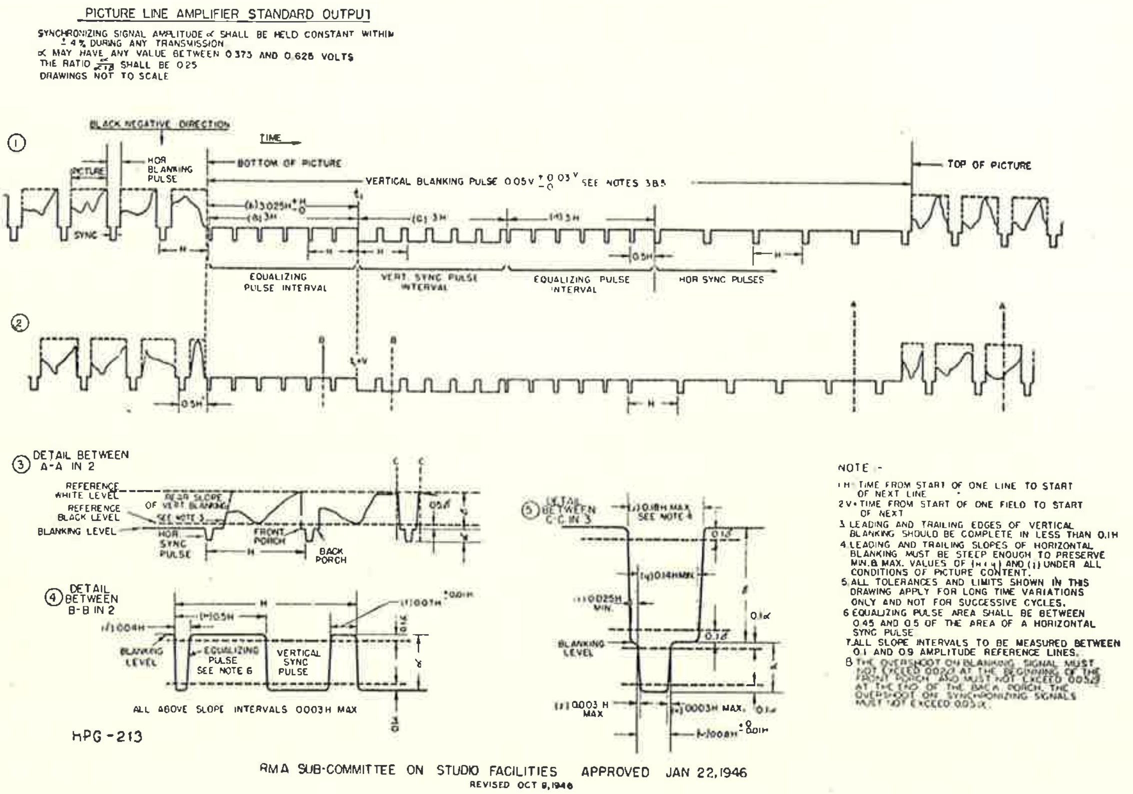


FIG. 4 (at left). Steps in the synthesis of picture signal:

A. Basic camera signal.
B. Kinescope blanking pulse.
C. Camera signal and blanking pulse combined.
D. Combined signal after clipping.
E. Combined signal after addition of sync pulse.

The blanking signal, shown only in part in Fig. 4, B, actually contains pulses for removing visible lines during both horizontal and vertical retrace periods. The horizontal pulses recur at intervals of



PICTURE LINE AMPLIFIER STANDARD OUTPUT

SYNCHRONIZING SIGNAL AMPLITUDE α SHALL BE HELD CONSTANT WITHIN ± 4% DURING ANY TRANSMISSION
α MAY HAVE ANY VALUE BETWEEN 0.375 AND 0.625 VOLTS
THE RATIO $\frac{\alpha}{\alpha+\beta}$ SHALL BE 0.25
DRAWINGS NOT TO SCALE

NOTE -

1 H: TIME FROM START OF ONE LINE TO START OF NEXT LINE
2 V: TIME FROM START OF ONE FIELD TO START OF NEXT
3 LEADING AND TRAILING EDGES OF VERTICAL BLANKING SHOULD BE COMPLETE IN LESS THAN 0.1H
4 LEADING AND TRAILING SLOPES OF HORIZONTAL BLANKING MUST BE STEEP ENOUGH TO PRESERVE MIN. & MAX. VALUES OF (x + y) AND (z) UNDER ALL CONDITIONS OF PICTURE CONTENT.
5 ALL TOLERANCES AND LIMITS SHOWN IN THIS DRAWING APPLY FOR LONG TIME VARIATIONS ONLY AND NOT FOR SUCCESSIVE CYCLES.
6 EQUALIZING PULSE AREA SHALL BE BETWEEN 0.45 AND 0.5 OF THE AREA OF A HORIZONTAL SYNC PULSE
7 ALL SLOPE INTERVALS TO BE MEASURED BETWEEN 0.1 AND 0.9 AMPLITUDE REFERENCE LINES.
8 THE OVERSHOOT ON BLANKING SIGNAL MUST NOT EXCEED 0.02α AT THE BEGINNING OF THE FRONT PORCH AND MUST NOT EXCEED 0.05α AT THE END OF THE BACK PORCH. THE OVERSHOOT ON SYNCHRONIZING SIGNALS MUST NOT EXCEED 0.05α.

RMA SUB-COMMITTEE ON STUDIO FACILITIES APPROVED JAN 22, 1946
REVISED OCT 8, 1946

FIG. 5. RMA drawing illustrating approved wave shape of picture line amplifier output signal. This is one of the most important industry standards and is the one which determines the design of many of the components of the TV system.

1/15,750 of a second and are only a small fraction of a line in duration, but at times corresponding to the bottom of the pictures they are replaced by *vertical blanking pulses* which are just like the horizontal pulses except that they are much longer in duration, approximately 15 scanning lines long, because the vertical retrace is much slower than the horizontal. The period of recurrence of the vertical blanking pulses is 1/60 of a second, of course. Both horizontal and vertical blanking pulses and their approximate relationship are shown in diagrams 1 and 2 of Fig. 5.

The picture signal shown in D of Fig. 4 may be considered as partly natural and partly synthetic. It is important to point out here that the natural part, or basic camera signal, may contain certain noise components arising from the fact that the output of the pickup tube usually is not large compared to the noise threshold of the first picture amplifier stage or some other part of the system such as the scanning beam in an image orthicon. On the other hand, the blanking pulses, or synthetic parts of the signal, are added at a relatively high level part of the system and are therefore noise-free. The importance of noise-free blanking pulses will become apparent in the discussions of other functions which they perform.

Details of horizontal blanking pulse shape are shown in diagram 5 of Fig. 5. That part of the diagram below the point marked Blanking Level is a sync pulse which will be considered later. The overall vertical dimension β is the maximum height of a blanking pulse. Thus the top horizontal line is Reference White Level as indicated in diagram 3. The duration or width of the pulse must be sufficient to cover the horizontal retrace in the most inefficient receiver. Thus the circuit limitations in such receivers set a minimum limit to the horizontal blanking width which was the basis for the RMA specification in Fig. 5. This minimum is indicated by the width near the peak (lower end) of the pulse and is prescribed by the sum of two dimensions $x + y$, the value of which is 16.5% of the horizontal period, H. The impossibility of producing infinitely steep sides on the pulse is recognized in the greater maximum width (18% of H) allowed at the upper end of the pulse and in the obviously sloped sides.

Because of inevitable discrepancies at the extremes of the sides of the pulse, all measurements of pulse widths are made at levels slightly removed from the extremes of the sides. These levels are shown by dotted horizontal lines, in diagram 5 of

Fig. 5, spaced 10% of β from top and bottom of the pulse.

Details of the vertical blanking pulses are shown in diagrams 1 and 3 of Fig. 5. The width of the pulses is not limited by circuit considerations, as is the width of horizontal blanking. The limitation here is the requirement of television film projectors of the intermittent type that the scene be projected on the pickup tube only during the vertical blanking period. The maximum period of 8% is ample for the operation of present-day film pickup systems, the criterion being that enough time must be allowed for projection so that there is adequate storage of photo-electric charges on the sensitive surface of the pickup tube. The minimum period of 5% is an indication of expected system improvements in the future when it will be possible to reduce waste of picture transmission time in vertical blanking. The present usefulness of the 5% minimum is to require receiver manufacturers to maintain vertical retrace periods at less than 5% and thus avoid the need for modifying old receivers when improvements are made in the system. The problem of film projectors is discussed in a later section.

The final step in synthesizing the complete composite picture signal which goes to the modulator in the transmitter is to add the synchronizing pulses which are required for triggering the scanning circuits in the receiver. These pulses, like blanking pulses, are essentially rectangular in shape. The blanking pulses serve as bases or pedestals (inverted) for the sync pulses as shown in E of Fig. 4. Here is one of the most important reasons for having noise-free blanking. The synchronizing function in the receiver is a very critical one, and it is important that nothing be allowed to distort the sync pulses either in shape or timing as noise during the blanking intervals would do. The nature of the vertical sync signal is rather complicated and is not illustrated in Fig. 4, but will be discussed later along with other details of synchronizing.

The sync signal is not added individually to the output of each camera, but is added at the studio output so that switching from one camera to another will not cause even momentary interruptions in the flow of synchronizing information to the receivers.

(This article will be continued in the next issue of Radiotronics.)

How The Image Orthicon Works

The 2P23 image orthicon is one of the most universally used television camera tubes. Its performance no doubt has been somewhat of a mystery to many readers, and for that reason the following has been reprinted from RCA Radio Service News by courtesy of the Radio Corporation of America.

The 2P23 has three sections — an image section, a scanning section, and a multiplier section, as shown in the diagram.

Image section

The image section contains a semi-transparent photocathode on the inside of the face plate, a grid to provide an electrostatic accelerating field, and a target which consists of a thin glass disc with a fine mesh screen very closely spaced to it on the photocathode side. Focussing is accomplished by means of a magnetic field produced by an external coil, and by varying the photocathode voltage.

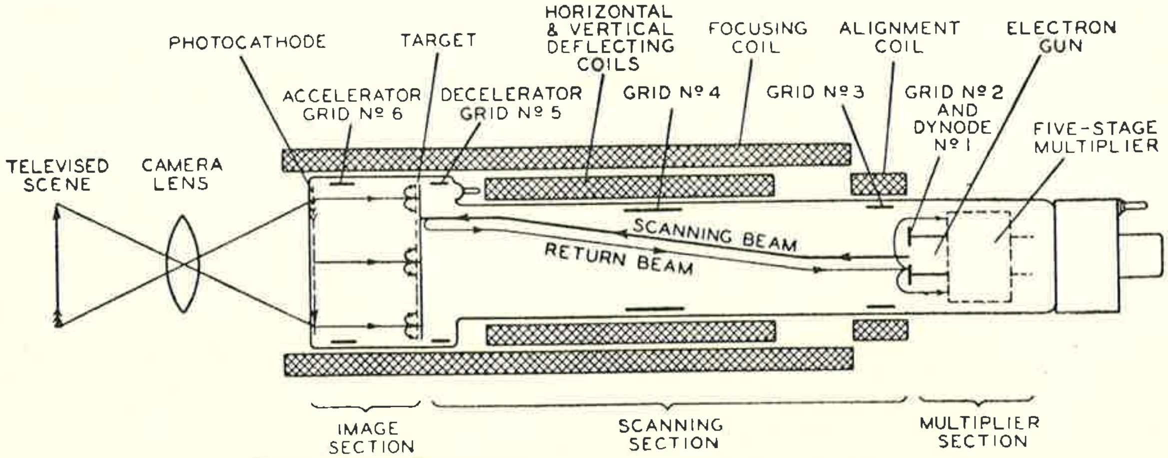
Light from the scene being televised is picked up by an optical lens system and focussed on the photocathode which emits electrons from each illuminated area in proportion to the intensity of the light striking the area. The streams of electrons are focussed on the target by the magnetic and accelerating fields.

On striking the target, the electrons cause secondary electrons to be emitted by the glass. The secondaries thus emitted are collected by the adjacent mesh screen which is held at a definite potential of about one volt. Therefore, the potential of the glass disc is limited for all values of light and stable operation is achieved. Emission of the secondaries leaves on the photocathode side of the glass a pattern of positive charges which corresponds with the pattern of light from the scene being televised. The charges set up a corresponding potential pattern on the opposite or scanned side of the glass.

Scanning section

The opposite side of the glass is scanned by a low-velocity electron beam produced by the electron gun in the scanning section. This gun contains a thermionic cathode, a control grid (grid No. 1), and an accelerating grid (grid No. 2). The beam is focussed at the target by the magnetic field of an external focussing coil and the electrostatic field of grid No. 4.

Grid No. 5 serves to adjust the shape of the decelerating field between grid No. 4 and the target



in order to obtain uniform landing of electrons over the entire target area. The electrons stop their forward motion at the surface of the glass and are turned back and focussed into a five-stage signal multiplier, except when they approach the glass. When this condition occurs, they are deposited from the scanning beam in quantities sufficent to neutralize the potential pattern on the glass. Such deposition leaves the glass with a negative charge on the scanned side and a positive charge on the photocathode side. These charges will neutralize each other by conductivity through the glass in less than the time of one frame.

Alignment of the beam from the gun is accomplished by a transverse magnetic field produced by an external coil located at the gun end of the focussing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

The electrons turned back at the target form the return beam which has been amplitude modulated by absorption of electrons at the target in accord with the charge pattern whose more positive areas correspond to the highlights of the televised scene.

Multiplier section

The return beam is directed to the first dynode of a five-stage electrostatically focussed multiplier. This utilizes the phenomenon of secondary emission to amplify signals composed of electron beams. The electrons in the beam impinging on the first dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid No. 3 facilitates a more complete collection by dynode No. 2 of the secondaries from dynode No. 1. The multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode No. 5 are collected by the anode and constitute the current utilized in the output circuit.

The multiplier section amplifies the modulated beam about 500 times. The multiplication so obtained increases the signal-to-noise ratio of the tube and also permits the use of an amplifier with fewer stages. The gain of the multiplier is sufficiently high so that the limiting noise in the use of the tube is the random noise of the electron beam multiplied by the multiplier stages. This noise is larger than the input noise of the video amplifier.

It can be seen that when the beam moves from a less positive portion on the target to a more positive portion, the signal output voltage across the load resistor changes in the positive direction. Hence, highlights in the scene produce an output signal voltage of positive polarity across the load resistor. As a result, the grid of the first video-amplifier stage swings in the positive direction.

NEW RCA RELEASE

Radiotron type 6CB6—is a sharp-cutoff pentode of the 7-pin miniature type designed especially for video i-f amplifier service at frequencies of the order of 40 megacycles. It is also well suited for use as a r-f amplifier in v-h-f television tuners.

The 6CB6 features very high transconductance combined with low capacitance values. Compared with the similar type 6AG5, the 6CB6 has about 25% higher transconductance and yet its grid-No. 1-to-plate capacitance is $\frac{1}{3}$ less when measured on a comparable basis.

In the 6CB6, grid No. 3 and cathode have separate base-pin terminals which permit the use of an unbypassed cathode resistor to minimize the effects of regeneration.

Use of Radiotron 5763 V-H-F Beam Power Amplifier as Frequency Multiplier up to 175 Megacycles

Reprinted from RCA Application Note AN-141 by courtesy of the Radio Corporation of America.

The Radiotron 5763 is a nine-pin miniature beam power amplifier developed for use in the low-power multiplier stages of high-frequency transmitters in which the operating requirements are too severe to be met adequately with receiving type valves. The small size of the 5763 and its high emission capability at low values of heater voltage make it particularly desirable for use either in compact mobile transmitters or in low-power stages of stationary equipment.

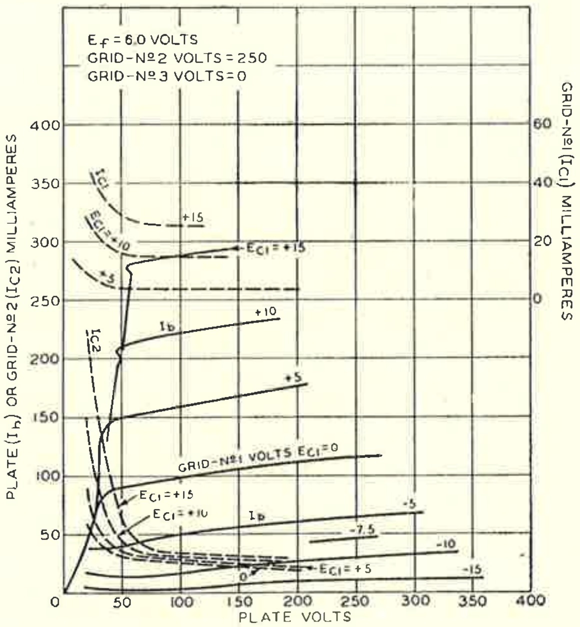


Fig. 1—Average characteristics of v-h-f beam power amplifier Radiotron-5763.

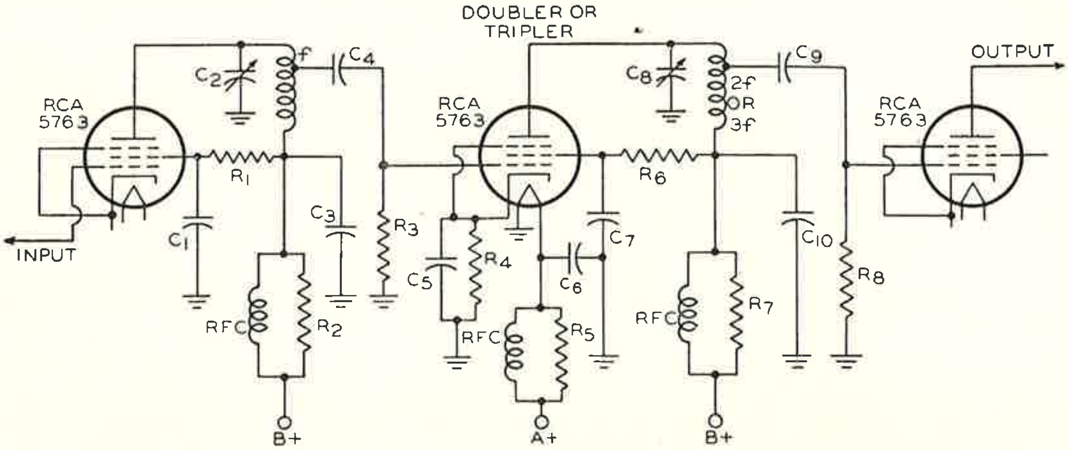
General considerations

The high-frequency characteristics of a valve in class C amplifier service depend in part upon the low-frequency properties of the valve such as: (a) high current at low plate voltage (because the r-f output peak voltage is subtracted from the supplied d.c. voltage to determine the actual instantaneous plate voltage), (b) a large change in plate current between cutoff and a moderately positive grid, and (c) sharp cutoff. In the curves of average plate characteristics for the 5763, given in Fig. 1, a grid—No. 1 voltage $E_{c1} = -15$ volts—may well be taken as the value for plate current cutoff at a plate voltage of 60 volts. A grid-voltage swing from –15 to +15 volts causes a 280-milliampere change in plate current. These increments in grid voltage and plate current show the effective amperes per volt to correspond approximately to 10000 micromhos, a high value for the conduction part of the cycle.

The peak value of cathode current required of a valve in class C amplifier service is high; in multiplier service, this value is increased because smaller plate-current conduction angles are required for efficient operation. Moreover, valves for mobile service are quite likely to be operated at heater voltages above or below rated values because of supply voltage variations. In order to take care of such operating conditions the 5763 is provided with a cathode having a large emitting area. In normal operation, the heater should be operated at 6.0 volts rather than the usual 6.3 volts. When this valve is used with stationary equipment having a 6.3-volt a.c. heater supply, a series resistor should be used to drop the heater voltage to 6.0 volts. Failure to observe this precaution is likely to result in slightly reduced valve life and a tendency toward grid emission at high line voltage. As a result of the heater and cathode design, the oscillator power output drops less than 10 per cent. for a change in heater voltage from 6.0 to 5.25 volts.

The 5763 has several features which contribute to its efficient performance at high frequencies. One of these features is the 9-pin miniature envelope with its integral base and stem which provides a structure with low values of lead inductance, reduced interelectrode capacitances, and low r-f losses. The low r-f losses permit application of full plate power input at frequencies up to 175 megacycles. It is well to note that above 125 megacycles, greater power gain is obtained when the valve is used as a doubler rather than as a straight-through neutralized power stage because loading of the driving stage due to the input resistance of 5763 is less severe at the lower frequency.

The 5763 has been designed so that a relatively high value of grid resistance (up to 100000 ohms) may be safely used. This high resistance value makes it possible to obtain the moderately high value of grid bias required for good multiplier plate-circuit efficiency with low values of d.c. grid current.



C1 C3 C5 C6 C7 C10: 5000 $\mu\mu$f, 500 volts
C2 C8: Tuning Capacitor, 1 – 8 $\mu\mu$f
C4 C9: 500 $\mu\mu$f
R1: 12500 ohms, 0.5 watt
R2 R5 R7: 100000 ohms, 1 watt, Allen-Bradley
R3 R8: 75000 ohms, 1 watt for doubler service; 100000 ohms, 1 watt for tripler service
R4: 62 ohms, 0.5 watt
R6: 12500 ohms, 1 watt
RFC: RF Choke, #24 enamel-covered wire close wound on resistors R2 R5 and R7

Fig. 2—Frequency-multiplier circuit.

Two control-grid connections, pins 8 and 9, are provided to aid in cooling the grid. These connections should be tied together at the socket. As a further aid to heat conduction, it is recommended that heavy copper leads be used for all grid and plate connections at the socket. The normal operating temperature of the valve is 200 to 250 degrees centigrade. Sufficient ventilation should be provided to keep the valve temperature within this range.

Application as frequency multiplier

In the circuit of Fig. 2, the 5763 is used as a frequency multiplier in a conventional manner. The same circuit employing tapped coils is used for either doubler or tripler operation. Although the use of tapped coils can lead to parasitics, no difficulty was experienced with the circuits described in this Note. Because of the high-amplification factor of the 5763, a small cathode resistance of 62 ohms can furnish sufficient bias voltage to protect the valve for a limited time in the event of temporary failure of excitation and resultant loss in bias developed by the grid resistor.

Radiotronics 139 includes the operating conditions for both doubler and tripler service. In general, best multiplier operation occurs with a high driving voltage and grid-No. 1 bias, which results in a small conduction angle, grid-No. 2 dissipation being the limiting factor. Fig. 3 gives the useful power output of the circuit of Fig. 2 in doubler and tripler service as a function of operating frequency. "Useful power output" is the power delivered to the grid of the following valve; it is equal to the valve power output less circuit and radiation losses. At 150 megacycles the power loss in the tank circuit of the multiplier is approximately 1.5 watts, a reasonable value for a high-frequency low-power circuit using "lumped" constants. When the circuit is used in a closely shielded transmitter additional losses will be encountered, depending on the design. In a compact mobile transmitter, for example, a total power loss of 3 watts for this circuit is not unreasonable. The driving power indicated in Fig. 3 is the power at the grid for either doubler or tripler operation.

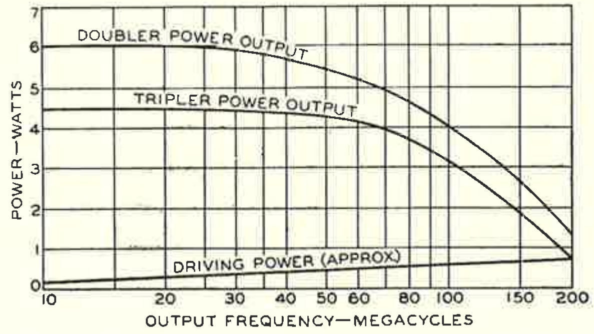
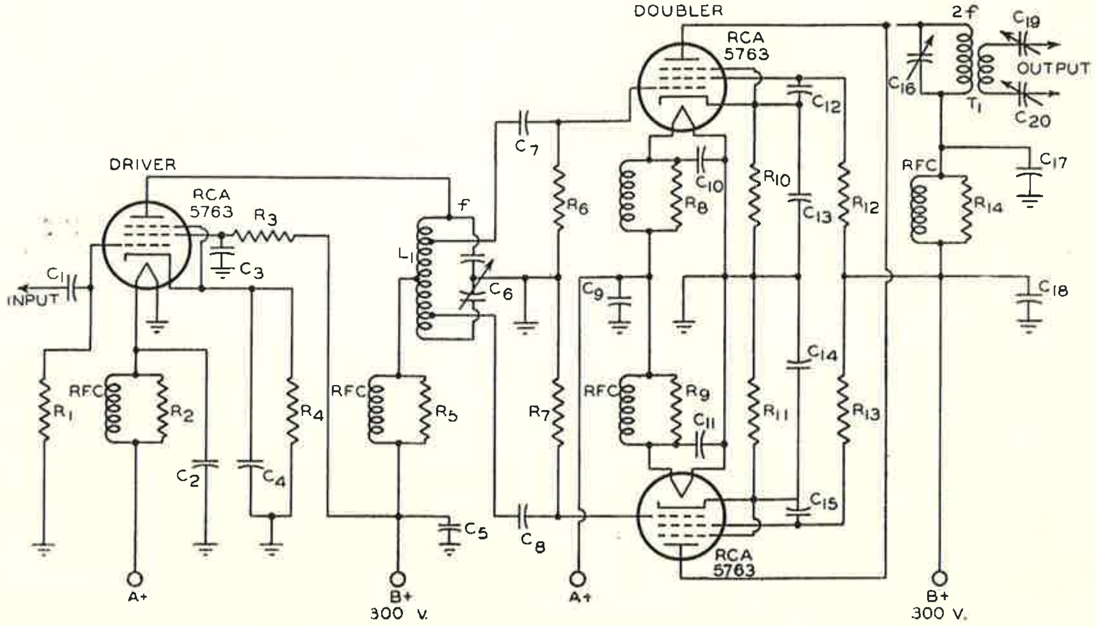


Fig. 3—Required driving power and useful power output as a function of frequency for frequency-multiplier circuit of Fig. 2.

"Push-push" doubler circuit

Fig. 4 is a "push-push" doubler circuit using a pair of 5763's. In this application, in which the plates of the valves are connected in parallel, the low value of output capacitance (4.5 $\mu\mu$F per valve) is



C1 C7 C8: 500 μμf
C2 C3 C4 C5 C9 C10 C11 C12 C13 C14 C15 C17 C18: 5000 μμf, 500 volts
C6: Split-stator tuning capacitor - value depends on operating frequency (f)
C16 C19 C20: Tuning capacitor - value depends on doubler frequency (2f)
L1: Tank inductance - value depends on operating frequency (f)

R1 R6 R7: 75000 ohms, 1 watt
R2 R5 R8 R9 R14: 100000 ohms, 1 watt Allen-Bradley
R3 R12 R13: 12500 ohms, 0.5 watt
R4 R10 R11: 62 ohms, 0.5 watt
RFC: RF choke, #24 enamel-covered wire close wound on resistors R2 R5 R8 R9 and R14
T1: Transformer - value depends on doubler frequency (2f)

Fig. 4—"Push-push" doubler circuit.

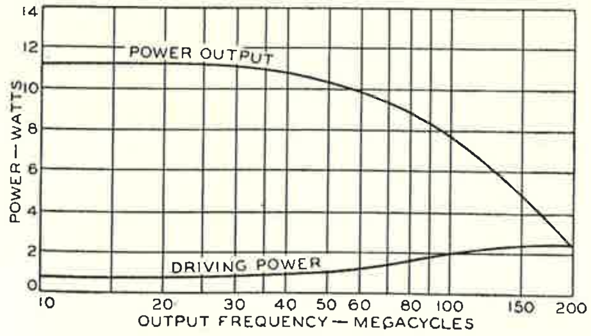


Fig. 5—Required driving power and useful power output as a function of frequency for "push-push" doubler circuit of Fig. 4.

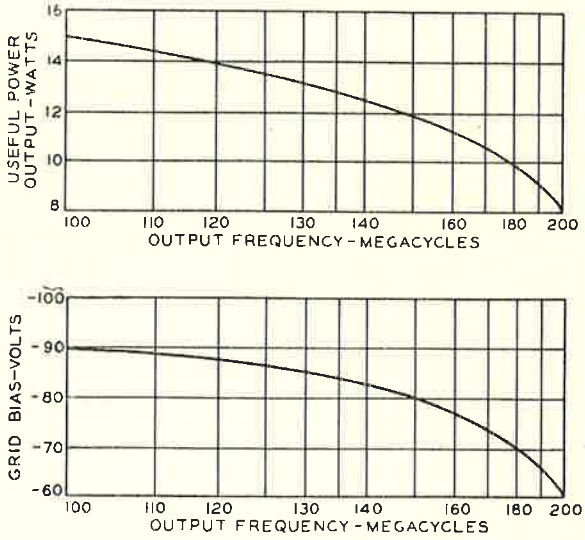


Fig. 6—Useful power output and grid bias as a function of frequency for neutralized 2E26 driven by "push-push" doubler circuit of Fig. 4.

advantageous. A single 5763 used as a tripler provides more than adequate driving power for the "push-push" doubler. This circuit arrangement is particularly suitable for low-power transmitters. The useful power output of this circuit as a function of operating frequency is given in Fig. 5. The driving power indicated is measured at the grids of the 5763's.

An important application of the 5763 is as a frequency doubler to drive the popular v-h-f transmitting valve 2E26. When the "push-push" doubler circuit is used to drive the 2E26 in a carefully neutralized circuit, the useful power output of the 2E26 and the developed grid bias voltage at the grid of the 2E26 obtained with a grid resistor of 30000 ohms are given in Fig. 6 for frequencies above 100 megacycles.

The useful power output of a properly neutralized 2E26 at 175 megacycles is shown in Fig. 7 as a function of driving power at the grid of the 2E26.

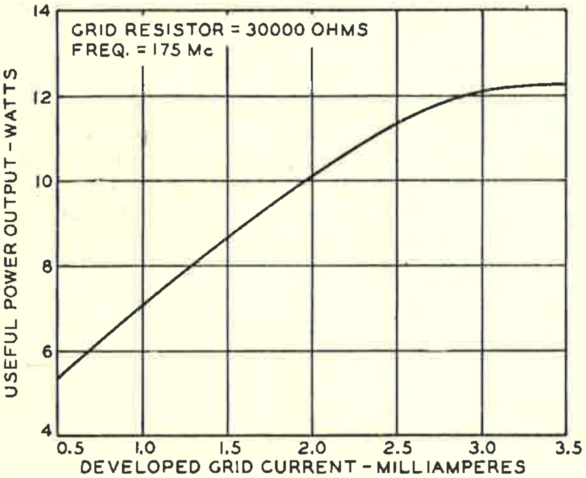


Fig. 7—Useful power output as a function of driving power for neutralized 2E26 at 175 megacycles.

Because of the possibility of spurious radiation resulting from the use of a final stage which is improperly neutralized, it may be preferable for mobile transmitters operated by non-technical personnel to substitute a doubler stage which does not require neutralization. In such cases, the use of a 5763 "push-push" doubler stage may be advantageous.

New
Noise Generator Diode
Radiotron Type A1468

≈CV172

This new valve will fill a long-felt want by engineers. It is a diode incorporating a directly-heated tungsten cathode and it is particularly suitable for use as a noise generator. When used in a simple circuit such as described in "Q.S.T." for September, 1947, the noise factor of a receiver can be readily determined.

In addition, this valve can also be used with very satisfactory results in bridge-type regulated power supplies as a saturated diode in one of the bridge arms, as mentioned in the June, 1947, issue of "Electronics".

It is mounted on the standard English 9 pin (B9G) base, and its characteristics are tabulated below. Stocks are expected in March.

Filament voltage	7 max. volts
Filament voltage spread (for sat. plate current of 30mA)	6.25-6.75 volts
Filament current (for fil. voltage of 6v)	1 amp. approx.
Average sat. plate current (for fil. voltage of 6V)	18 mA
Plate to filament capacitance	1.2 μμF
Pin connections	Do not use pin 5
Plate	Pins 2, 3, 7 & 8
Filament	Pins 1 & 9
Max. overall height	3 in.
Max. seated height	$2\frac{7}{16}$ in.
Max. diameter	$1\frac{1}{2}$ in.

RCA Receiving Tube Manual

Copies of the RCA Receiving Tube Manual (RC15) are now available from A.W. Valve Company, 47 York Street, Sydney. Price, 5/9 each.

BACK NUMBERS

The following issues of Radiotronics are no longer available: 117, 118, 121, 122, 123, 124, 125, 126, 127, 128, and 129.

Television Antennas and Transmission Lines*

By *JOHN R. MEAGHER*

Television Specialist, RCA Renewal Sales.

PART 1. ACTION OF DIPOLE AND REFLECTOR

Assume that the metal rod in Fig 1 is supported horizontally in space to pick up signals from a TV station. The rod is cut to one-half wave length at the frequency of this station. The rod is not broken at the centre, and it is not connected to anything.

The rod will intercept or pick up signals from a limited area of space that for practical purposes may be regarded as being almost as long as the rod and about a half-wave high.

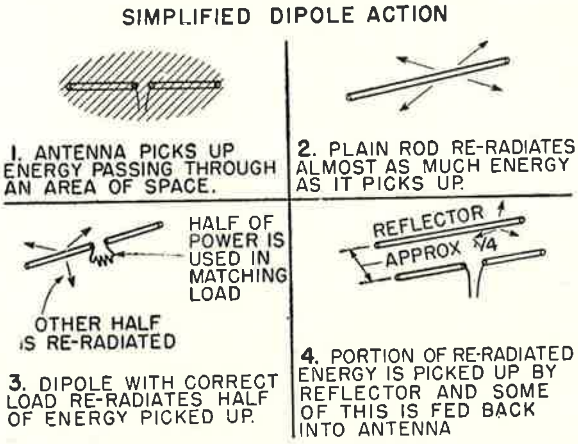


Fig. 1.

A small amount of this signal will be used up in heat (current flow along the surface of the rod). The rest of the signal cannot be absorbed because there is no load. So essentially all of the signal that is picked up by the rod is re-radiated or sent out again into space.

Suppose we break the rod at the centre and connect an adjustable resistance across the gap. Also, suppose that we provide some means to measure the power in this resistor, which is the load. We then adjust the resistance for the value that develops maximum power in the resistor.

Under this condition, we can assume that one-half of the energy picked up by the antenna is absorbed in the load, and the other half is re-radiated. For convenience we can assume that the re-radiated energy is consumed in another resistance, which is termed the radiation resistance.

Some of this re-radiated energy can be reflected back into the antenna by placing another rod (reflector) of suitable length in back of the antenna with a spacing of one-quarter wave or less.

The reflector picks up some of the energy that is re-radiated by the antenna. In turn, the reflector re-radiates practically all of this energy, and a portion of this is picked up by the antenna.

The antenna is now getting energy from two sources, from the station and from the reflector. For best results, these two must be in step (or phase) with each other at the antenna. This phase relationship depends on the spacing between antenna and reflector, and on the length (tuning, or phase) of the reflector.

The reflector acts to increase the energy in the antenna and also to decrease the radiation resistance. In effect, less energy is re-radiated by the antenna and more energy is used in the load.

The same results can be achieved by placing a rod in front of the antenna. In this position it is called a director. The two signals arriving at the antenna, also must be in phase; the phase relation in this case depends on the spacing between the antenna and director and on the length (tuning or phase) of the director.

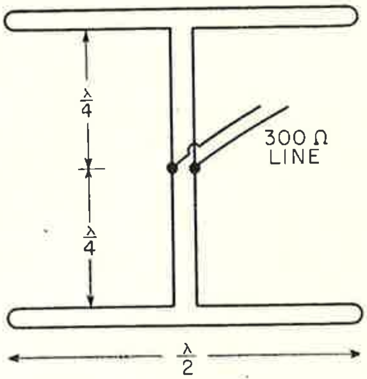


FIG 2

In TV reception, a practical difference between a reflector and a director is that with a reflector, the response is cut more sharply on the low-fequency side; with a director, the response is cut more sharply on the high-frequency side.

The use of both a director and a reflector results in greater gain, but with narrow band width and low antenna impedance.

---

* Reprinted from RCA Radio Service News (Nov.-Dec. 1948) by courtesy of the Radio Corporation of America.

Stacked antennas

An antenna intercepts or receives the signal in a certain area of space. If two similar antennas are used, the intercepted area is doubled and the received *power* is doubled. When two antennas are connected together, with current phasing and matching, the *voltage* across the input impedance of the receiver is increased approximately 1.4 times.

Figure 2 shows a practical example, using two identical folded dipoles spaced one-half wave apart. If reflectors with spacing of 0.2 wave-length are used, it may be assumed that the impedance of each antenna is reduced to about 170 ohms. (For simplicity, the reflectors are not shown in Figure 2.)

The transmission-line impedance is 300 ohms. At the point where the line connects to the two antennas, the impedance of each antenna should "look like" 600 ohms, so that the two in parallel are 300 ohms.

Two quarter-wave lines are used as matching sections between the terminals of each antenna and the transmission line. These quarter-wave lines should have an impedance that will "transform" the impedance of each 170-ohm antenna up to 600 ohms. The quarter-wave line impedance can be computed from the relation:

$$\text{Line impedance} = \sqrt{\text{input impedance} \times \text{output impedance}}$$

In this example the

$$\text{Line impedance} = \sqrt{170 \times 600}$$
$$= 320 \text{ ohms approximately.}$$

{Corrn. ex P.41}

When tubing or rods are used for the matching sections, the diameter spacing for an impedance of 320 ohms can be determined from Figure 3. Rods of $\frac{1}{4}''$ diameter spaced 1.8" or rods of $\frac{3}{8}''$ diameter spaced 2.8" are suitable in this case.

The phasing or polarity of the signal voltage from each antenna is automatically taken care of in this arrangement because the signal from each antenna travels the same distance ($\frac{1}{4}$ wavelength) to reach the transmission-line terminals.

When stacked arrays for low-band channels are installed, it should be remembered that if the top antenna is not very high above the effective ground plane, the lower antenna will intercept less signal than the top antenna. As a result, the actual voltage gain of the array, compared to the top antenna alone, will be less than 1.4.

The effective ground plane may be at roof level in a building with metal framing or a metal roof.

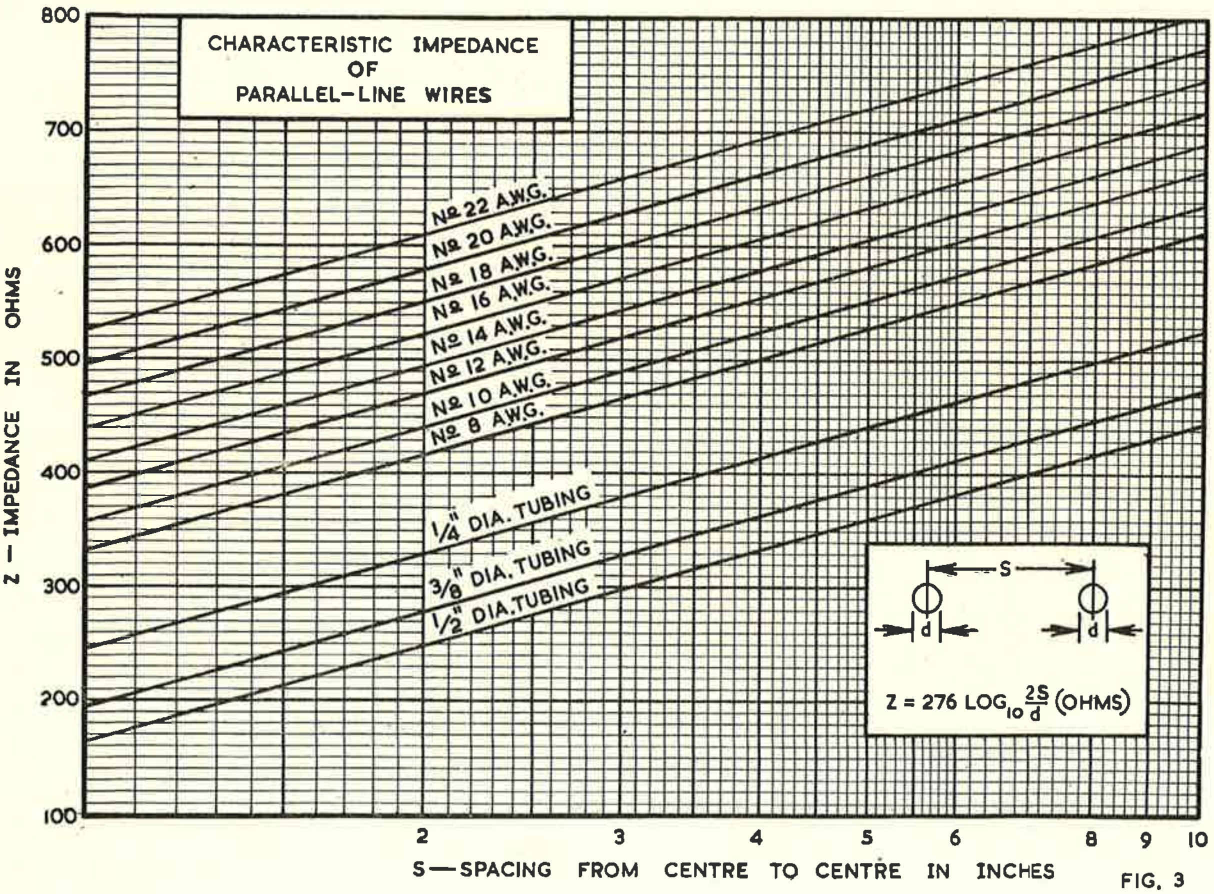


FIG. 3

Folded dipoles

In a conventional folded dipole, as shown in Fig. 4a, with rods of equal diameter, each rod has $\frac{1}{2}$ the total conducting areas, and the impedance is 4 times that of a plain dipole.

The impedance of a folded dipole may be increased by increasing the area of the continuous section, or by using more than one rod in parallel with the split section, as shown in Figs. 4b and 4c. When the split section has 1/3 the total area, the antenna impedance has 9 times that of a plain dipole. When the split section has $\frac{1}{4}$ the total area, the impedance is 16 times that of a plain dipole.

IMPEDANCE OF FOLDED DIPOLES

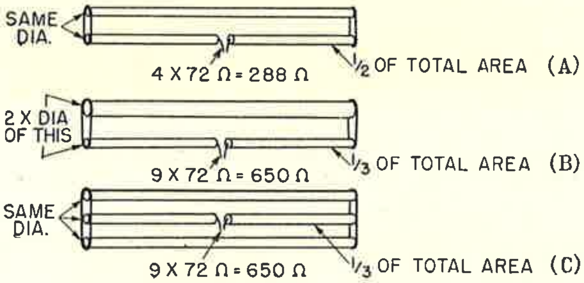
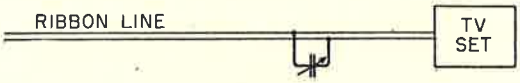


FIG. 4

IMPROVING SIGNAL
WHEN TV SET DOES NOT CORRECTLY TERMINATE LINE



1. FIND POINT WHERE FINGERS INCREASE SIGNAL.
2. CONNECT SMALL TRIMMER AT THIS POINT, ADJUST FOR BRIGHTEST PIX.

(USEFUL ONLY ON WEAK SIGNAL)

FIG. 5

The presence of a reflector decreases the impedance of a folded dipole in the same ratio as for a plain dipole.

When both reflectors and directors are used to obtain maximum gain, the impedance of a plain dipole may drop to as low as 10 ohms. This value is too low for connection to a coax transmission line. However, a folded dipole with several parallel elements as shown in Figs. 4b or 4c, may be used in place of the plain dipole to obtain a higher antenna impedance to facilitate matching to a coax transmission line.

In some respects, a folded dipole may be regarded as a plain dipole shunted by two quarter-wave shorted stubs. The stubs function as parallel-tuned circuits, while the dipole functions as a series-tuned circuit. The reactances of the stubs and the dipole change in opposite directions and tend to cancel at frequencies above or below resonance. This tendency contributes to the somewhat wider bandwidth of a folded dipole as compared to that of a plain dipole.

Increasing signal input on an incorrectly terminated line

As mentioned later, the impedance of the transmission line should equal the *rated* input impedance of the particular TV receiver. However, the *actual* input impedance of TV receivers does not remain constant on all channels, and frequently has a large reactive component. By "tuning out" this reactance on any particular channel, it is possible in many cases to get an appreciable increase in picture strength. Obviously, this expedient is required only on weak signals.

This improvement can be accomplished easily on installations with *ribbon*-type transmission line. The procedure is as follows:

1. Tune in the weakest TV station.
2. Grasp the transmission line between the thumb and fingers at some point along the line where it is convenient to observe the picture. Slide the fingers along the line, watching for change in picture brightness. At some point, the picture strength will increase. A quarter-wave further along the line, the picture strength will decrease.

The fingers act as a small capacitor across the transmission line. It may be necessary to vary the capacitance by increasing or decreasing the pressure or the finger area. If the effect of a larger capacitor is required, grasp the line between the palm and four fingertips.

Find the centre point of the section where the hand capacitance increases the picture strength. Connect a small silvered ceramic trimmer (1.5 to either 7 to 15 $\mu\mu$F) across the transmission line at this point. Hold the insulation of the trimmer between the tips of the fingers and, using a fibre neut stick, adjust the trimmer for maximum picture strength. Refer to Figure 5.

Instead of a trimmer capacitor, it is possible to use a piece of metal foil, wrapping it around the line, sliding it to the position for best signal strength, adding or removing foil area if necessary, and finally fastening it in position with Scotch tape.

If hand capacitance decreases the picture strength at all positions along the line, it indicates that the receiver is correctly terminating the line on the particular channel. In this case, no improvement can be achieved.

The actual application of this method of partially compensating for an incorrectly terminated line depends on how many channels need improvement, whether a particular receiver has appreciable input reactance on these channels, and many other factors. We will leave, therefore, the actual application to the ingenuity of the TV technician. It should be noted, however, that the particular position and value of the capacitance apply only to one channel. For any other channel it is necessary to reposition the capacitor and change its value.

(This article will be continued in the next issue of Radiotronics.)

See also P.1.

New Radiotron Miniature Voltage Regulators

Useful additions to the Radiotron 7-pin Miniature series of valves are the four voltage regulators whose principal characteristics are listed below. Stocks of all these types are expected to be available during March. In the great majority of circuit designs these new types can be used whenever a regulated voltage at moderate currents is required.

In common with all gas discharge devices these voltage regulators require for ignition a voltage greater than the working voltage. This value for individual types is quoted in the table, and must be applied to the valve through a series resistance.

This series resistance absorbs the excess voltage after ignition, and prevents a heavy discharge current through the valve, and the d.c. resistance of the latter can be regarded as negligible.

In certain cases, where a heavy load is permanently shunted across the valve, difficulty may be experienced in obtaining sufficient voltage across the valve gap to cause ignition. To overcome this an auxiliary electrode, known as the "ignition electrode", is fitted, and this ensures satisfactory operation under the conditions referred to above.

The ignition electrode voltage is applied through an ignition-electrode resistance from a higher voltage source, but if required, the voltage may be taken from a separate supply. The value of this resistance for each type is shown in the table below.

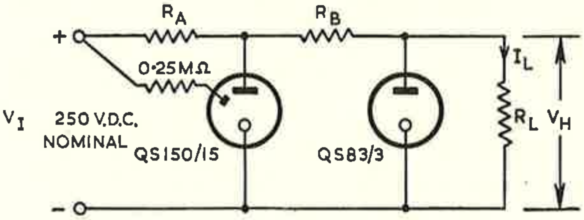


Fig. 1—Circuit showing use of voltage regulators in cascade.

The QS 83/3 has been designed to serve mainly as a reference source of voltage in series-type power supplies requiring close regulation. Alternatively it may be used independently, or in conjunction with another regulator where the performance require-

	QS70/20	QS83/3	QS95/10	QS150/15
Striking voltage	105	130	110	170
Operating voltage	70	83	95	150
Ignition electrode voltage	—	—	150	240
Ignition electrode resistance (MΩ)	—	—	0.25	0.25
Operating current max. (mA)	20	5	10	15
Operating current min. (mA)	2	1	2	2
Regulation over current range (V)	6	0.6	5	5
Maximum overall length (in)	2⅛″	2⅛″	2⅛″	2⅛″
Maximum seated length (in)	1⅞″	1⅞″	1⅞″	1⅞″
Maximum diameter (in)	¾″	¾″	¾″	¾″
Base connections—		do not connect to 3 & 6		
Anode	Pins 4 & 7	1 & 5	5 & 7	5 & 7
Cathode	1 & 3	2, 4 & 7	1 & 3	1 & 3
Ignition electrode	—	—	4	4
Similar RCA types	0A3/VR75	5651	0C3/VR105	0D3/VR150

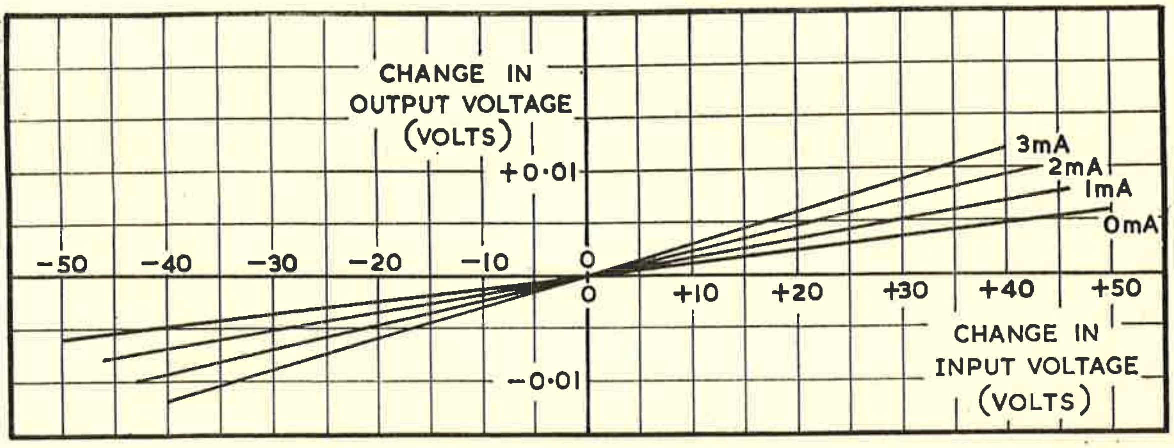


Fig. 2—Variation of output voltage with changes in input voltage for load currents from 0-3mA using a QS. 150/15 and a QS.83/3 in cascade.

ments necessitate it. The maximum variation of voltage at a constant current of 3 mA (the suggested working current), is 0.1%.

In order to obtain the most stable output, less than 0.1% change in voltage over long periods, it is necessary to stabilise the input voltage to the voltage reference tube. This is most easily done by cascade connecting a suitable stabiliser and the QS.83/3.

The circuit shown in Fig. 1 is recommended when a very stable voltage of approximately 83 volts is required, the load should draw a constant current, which may have any value up to 3 mA. The values of the circuit parameters are tabulated below for load currents from zero to 3 mA, and the permissible change in input voltage V_1, nominally 250V, is also given, together with the consequent change in output voltage, V_H.

These figures are based on the average characteristics of the valves, and some variation from valve to valve may be expected.

The accompanying curves show limits of input voltage, and the variation in output voltage for various loads.

If a different voltage, or a current greater than 3 mA is required, it is necessary to employ one of the constant voltage networks, such as the series valve stabiliser, using a QS.83/3 as the voltage reference source for the network.

I_L	R_L	R_A	R_B	Max. Change in V_1 from	Change in V_H
(mA)	(ohms)	(ohms)	(ohms)	250V.	(V.)
0	Infinite	8,350	22,300	± 50	± 0.006
1	83,000	7,700	16,700	± 46	± 0.008
2	41,500	7,150	13,400	± 43	± 0.010
3	27,600	6,670	11,200	± 40	± 0.012

Radiotron L77/6C4 H-F Miniature Power Triode

The L77/6C4 is a heater-cathode type of miniature valve intended for use as class C amplifier and oscillator in compact, light-weight, portable equipment, but it is useful in other applications where a medium-mu miniature triode with high transconductance is desired. In class C service, the L77/6C4 will deliver a power output of about 5.5 watts at moderate frequencies, and 2.5 watts at 150 megacycles. This valve is a very satisfactory miniature substitute for the older type 6J5-GT.

HEATER VOLTAGE (a.c. or d.c.)■	6.3	Volts
HEATER CURRENT	0.15	Ampere
DIRECT INTERELECTRODE CAPACITANCES:*		
Grid to Plate [C_{gp}]	1.6	μμF
Grid to Cathode [C_g $(h + k)$]	1.8	μμF
Plate to Cathode [C_p $(h + k)$]	1.3	μμF
MAXIMUM OVERALL LENGTH		$2\frac{1}{8}''$
MAXIMUM SEATED HEIGHT		$1\frac{7}{8}''$
MAXIMUM DIAMETER		$\frac{3}{4}''$
BULB		T-5-1/2
BASE	Miniature	Button 7-Pin
MOUNTING POSITION		Any

* With no external shield.

BASE CONNECTIONS —

Pin 1 — Plate	Pin 5 — Plate
Pin 2 — I.C.	Pin 6 — Grid
Pin 3 — Heater	Pin 7 — Cathode
Pin 4 — Heater	

A-F Amplifier

PLATE VOLTAGE		300 max.	Volts
PLATE DISSIPATION		3.5 max.	Watts
CHARACTERISTICS — Class A_1 Amplifier:			
Plate Voltage	100	250	Volts
Grid Voltage**	0	−8.5	Volts
Amplification Factor	19.5	17	
Plate Resistance	6250	7700	Ohms
Transconductance	3100	2200	Micromhos
Plate Current	11.8	10.5	Milliamperes

** The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer- or impedance-coupling devices are recommended. Under maximum rated conditions, the resistance in the grid circuit should not exceed 0.25 megohm with fixed bias, or 1.0 megohm with cathode bias.

R-F Power Amplifier & Oscillator — Class C Telegraphy

D.C. PLATE VOLTAGE	300 max.	Volts
D.C. GRID VOLTAGE	−50 max.	Volts
D.C. PLATE CURRENT	25 max.	Milliamperes
D.C. GRID CURRENT	8 max.	Milliamperes
PLATE DISSIPATION	5 max.	Watts
TYPICAL OPERATION:‡		
D.C. Plate Voltage	300	Volts
D.C. Grid Voltage	−27	Volts
D.C. Plate Current	25	Milliamperes
D.C. Grid Current (Approx.)	7	Milliamperes
Driving Power (Approx.)	0.35	Watt
Power Output (Approx.)	5.5	Watts

‡ Approximately 2.5 watts can be obtained when the L77/6C4 is used at 150 Mc/s as an oscillator with grid resistor of 10,000 ohms and maximum rated input.

■ In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40).