



VISUAL INDICATOR TUBES



By R. LORENZEN

IN A PRECEDING article¹ the theory and applications of the shaded sector visual indicator tubes was discussed. There are, however, two additional types of these tubes, namely, the dual indicator type and the annular ring type.

tubes, but the results were still somewhat unsatisfactory. What was needed was a visual indicator tube that would operate equally well for both weak or strong signals. The dual indicator tube is the answer to that problem. Since it possesses two control electrodes, each controlling its own individual shaded pattern, one of the shadows can be made operable for weak signals and the other for strong signals.

DUAL INDICATOR

It is necessary, in the case of visual indicator tubes having only one control electrode, to adjust the avc voltage to just close the shaded angular pattern when the receiver is tuned to the strongest carrier. This results in a lack of visual indication sensitivity for weak signals. Such insensitivity was partially remedied by employing a variable-mu triode as a component part of these

CONSTRUCTION

Although the principles of operation of dual indicator tubes are fundamentally the same as those for the shaded sector type, there are some important differences that should be considered. All other types of visual indicator tubes are composite structures. They are comprised of the indicator tube proper and a triode control tube in the same envelope. The dual indicator tube, on the other hand, is only an indicating tube and obtains its control voltages from a special control tube. Furthermore, whereas all other visual indicator tubes have a standard 6-pin base, the dual indicator types (Fig. 2) employ the standard octal base.

Fig. 1 shows the construction of a dual indicator tube; 1A is a top view and 1B a side view. The cathode (K) is surrounded by a target current control grid (G) which is internally connected to the cathode. This target current control grid limits the target current to safe values, thereby preventing overheating of the tube. A cathode shield (CS) is located so as to prevent direct light from the hot cathode from being visible. The control electrodes V₁ and V₂ are thin metal vanes which are supplied various potentials by a control tube and thus cause a change in the openings of the shaded angular patterns on the target.

Each of the two ray-control vanes have identical characteristics. When the potential between a ray-control vane and the cathode is zero the shaded sector will have an angular opening of approximately 90°. If the ray-control vane voltage is about half the voltage between target and cathode the shadow angle will just close. On the other hand, when the ray-control vane voltage is negative with respect to the cathode the shaded angular shadow will be greater than 90° and may open to 160°. The

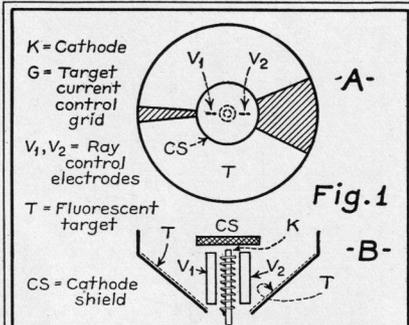


Fig. 1

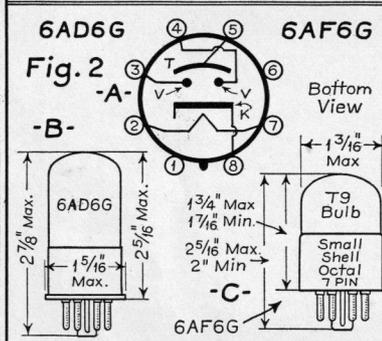


Fig. 2

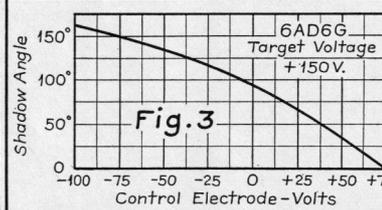


Fig. 3

The constructional details, base connections and characteristics of dual indicator tubes are given in Figs. 1, 2 and 3, respectively. The base connections and internal construction of the 6AE6G control tube are shown in Figs. 4 and 5, respectively. The two tubes used together can be used to give visual resonance indication over a very wide range. One shadow of the dual indicator can be made to close to a fine line with the application of -7 volts to the control grid of the 6AE6G tube, while the other shadow will remain almost fully open to the 6AE6G control grid.

Characteristics of Dual Indicator Tubes

6AD6G		
Indirectly heated cathode		
Heater voltage	6.3 V.	
Heater current	0.15 Amp.	
Target voltage	100V.	150V.
Ray-control electrode voltage		
0° Shadow	+45V.	+75V.
90° "	0V.	+8V.
135° "	-23V.	-50V.
Target current		
0° Shadow angle	1.5 Ma.	3.0 Ma.
90° "	1.0 "	2.0 "
135° "	0.8 "	1.2 "
Maximum overall length	2 7/8" Max.	
bulb dia.	1 3/16" Max.	
base "	1 5/16" Max.	
Bulb	T-9 Base - Small octal T-Pin	

6AF6G		
Indirectly heated cathode		
Heater voltage	6.3 V.	
Heater current	0.15 Amp.	
Overall length	2" to 2 5/16" Max.	
Bulb	T-9 Base - Small octal T-Pin	
Target voltage	100V.	135V.
Target current (with 0 volts on ray-control electrodes)	0.9 Ma.	1.5 Ma.
Ray-control electrode voltage		
0° Shadow angle	60V.	81V.
100° "	0V.	0V.

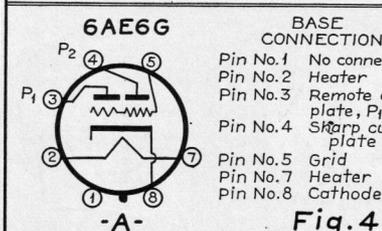


Fig. 4

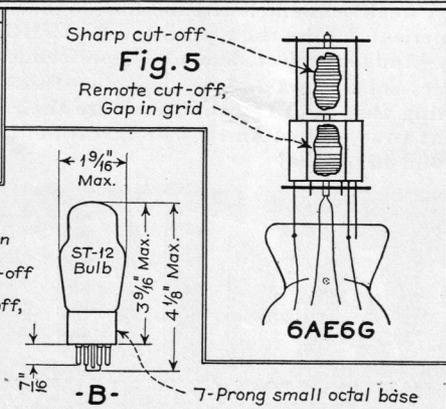


Fig. 5

¹"Visual Indicator Tubes", by R. Lorenzen, SERVICE, Oct., 1938, p. 7.

variation in the shaded angular opening with variation of the ray-control vane voltage for a 6AD6G dual indicator tube having a target voltage of 150 volts is shown in Fig. 3.

CONTROL TUBE

Although it is possible to use a dual-indicator tube in particular circuits without also using a special control tube, in order to operate these tubes to full advantage they are generally used in conjunction with a control tube, such as the 6AE6G.

The 6AE6G (Fig. 4) is comprised of a heater; a single cathode; a single grid, wound in two parts and two plates. The special grid construction is shown in Fig. 5. One half of the grid is comprised of evenly spaced grid wires, the other half of unevenly spaced grid wires. The evenly spaced portion of the grid controls the electronic flow to the sharp cut-off plate P_s , while the unevenly spaced portion of the grid, which results in a variable mu characteristic, controls the electronic stream to the remote cut-off plate P_r .

DUAL INDICATION

The circuit shown in Fig. 6 is intended for dual indication tuning, that is, one of the shaded sectors will close for weak signals and the other shaded angular pattern closes for a resonant condition on strong signals. Furthermore, these two operations are coordinated so that the "strong signal shadow angle" begins to operate when the "weak signal shadow angle" has just closed. For a strong signal both shadow angles are closed.

This difference in response is due to the fact that the two output control voltages from the control tube are very different since the "weak signal plate" (sharp cut-off plate) is regulated by an evenly spaced section of grid while the "strong signal plate" (remote cut-off plate) is influenced by an unevenly spaced section of grid.

An avc potential of -7 volts just closes the "weak signal shadow angle," whereas it takes approximately -27 volts to close the "strong signal shadow angle." Each of the shadow angles will open to about 160 degrees, if the circuit of Fig. 6 is used.

It will be noted that the cathode of the dual indicator tube is operated at a potential of 100 volts positive. This is done in order that the ray-control vanes may be made negative with respect to the cathode over part of their operating characteristic, the necessity for which will be understood by referring to Fig. 3.

The maximum permissible target volt-

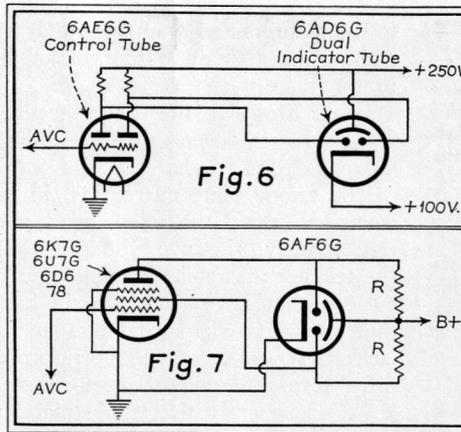


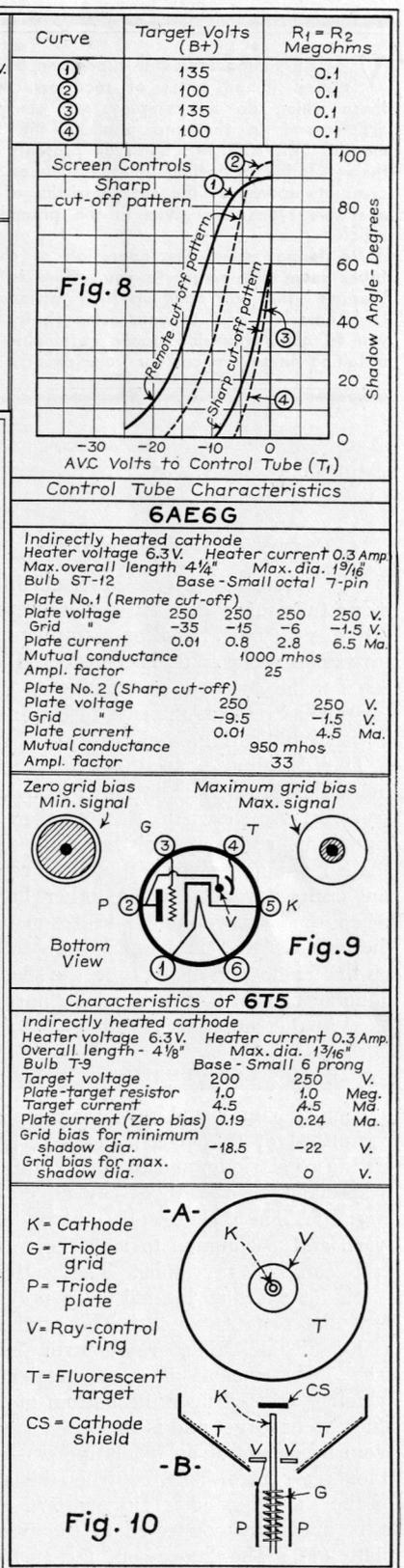
Fig. 6 shows a circuit for dual indication using the 6AE6G tube for control. A similar circuit is shown with a voltage amplifier pentode as the control tube, in Fig. 7. Characteristics of the 6AE6G tube are listed and shown graphically in Fig. 8. Figs. 9 and 10 are the base connections and characteristics and the constructional details of the 6T5 annular ring type visual indicator. This type is the electrical equivalent of the 6G5 described in the October issue of SERVICE. The bulb shape, however, is somewhat different.

age for a dual indicator tube is 150 volts. In Fig. 6 it might appear that this value has been exceeded. This is not the case, however, for, since the cathode is 100 volts positive, the target potential with respect to cathode is 150 volts.

Dual indicator tubes are sometimes erroneously called "twin indicator tubes." The term "twin indicator" is only appropriately applied when both ray-control vanes are connected to the same controlling source, the shadow angles then varying simultaneously and in an identical manner.

PENTODE CONTROL TUBE

A pentode, such as a 6K7-G, 6U7-G, 6D6, or 78, may be used as a control tube so that dual indication is obtained when used with a dual indicator tube. Such a circuit is shown in Fig. 7. The screen grid gives a sharp cut-off characteristic such that the ray-control electrode to which it is connected will close the shadow angle for low avc voltages. The plate, on the other hand, gives a remote cut-off characteristic such that



the ray-control vane to which it is connected will cause practically no motion of the shadow angle for low avc voltages, but will just start to close when the sharp cut-off shadow angle is entirely closed. The remote cut-off shadow angle will close the shadow angle for high avc voltages. The variation of shadow angle for various values

VISUAL tuning indicator tubes can be installed in all types of receivers, even those which do not employ avc. In this article and in the one published in last month's SERVICE, Mr. Lorenzen presents the theory and applications of these tubes. A complete survey of the characteristics of all available types was given in the preceding article.¹

No longer need the operation of these tubes seem like magic to you. Here is the "sesame" that will open up their intricacies. It is now left only to your sales ability for you to glean the rich booty obtainable by installing these devices for your clients.

of target voltage and plate-target resistor and for various avc voltages is shown in Fig. 8.

ANNULAR RING INDICATOR

The annular ring type of visual indicator tube, of which the sole representative is the 6T5, has been manufactured for some years. It is considered by some to be superior to the shaded sector type as regards the ease of obtaining a visual indication.

The doughnut-shaped pattern varies in size as the carrier is tuned in by the receiver. As shown in Fig. 9, when no signal is received by the radio the shaded annular ring will almost cover the entire target. On the other hand, when a station is tuned to resonance, thereby applying maximum avc voltage on the triode grid of the tube, the shaded annular ring will contract to a narrow band at the center of the tube.

CONSTRUCTION

Annular ring visual indicator tubes are comprised of two parts, one part consisting of a triode, and the other part of a special type of cathode-ray tube (see Fig. 10). The cathode (K) extends upward and is common to both the triode and cathode ray tube. The cathode shield (CS) is so located as to prevent any direct light from the hot cathode being visible. The ray-control electrode (V) consists of a flat metal ring which is located near the bottom of the fluorescent target and is separated therefrom by means of an insulating washer. This ray-control ring controls the size of the shaded annular ring pattern and it is internally connected to the triode plate (P). The fluorescent target (T) is inclined at an angle with respect to the cathode.

In the circuit for the 6T5 annular ring type of visual indicator tube, a resistance (R) is connected between the triode plate (P) and the fluorescent target (T). The target is connected directly to B+ and is always at this potential. The plate voltage, and, therefore, the potential of the ray-control ring (V), since it is directly connected

to the plate, is less than the supply voltage by the amount of the voltage drop in the plate-target resistor (R). The voltage drop in the plate-target resistor (R) is dependent upon the plate current of the triode.

The triode plate current is, in turn, dependent upon the triode grid potential, namely, the avc voltage. When the triode grid is biased to plate current cut-off, that is, when the grid has so high a negative potential that no plate current flows, there will be no voltage drop across the plate-target resistance R. Consequently the triode plate, and therefore the ray-control ring also, will have the same potential as the fluorescent target. Such a state of affairs results when the radio receiver is exactly tuned to the carrier frequency of the transmitting station, for then, a maxi-

vicinity of the ray-control ring. As a result, a narrow shaded annular ring occurs near the center of the tube.

The opposite extreme to the case just given occurs when the set is tuned so as not to receive any signal. Under these conditions there will be no avc voltage and, consequently, zero volts will be applied to the triode grid. Plate current will flow and a considerable voltage drop will be developed across the plate-target resistor (R). Since the triode plate voltage, and therefore the ray-control ring voltage, is the target voltage minus the voltage drop in the plate-target resistor, it is seen that the ray-control ring is of much lower positive potential with respect to the cathode than the target is. Or, looking at this from a different point of view, the ray-control ring is highly negative with respect to the target. Under these circumstances a strong electrostatic field will exist between the target and the ray-control ring, and this will be of such nature as to strongly repel electrons away from the vicinity of the ray-control ring. In consequence, the entire target surface will become shaded except for a narrow illuminated ring at the periphery where electrons still strike the target.

The 6T5 has identical electrical characteristics and external dimensions as the 6U5 described in a previous article¹ and is interchangeable with it. The 6T5, furthermore, has identical electrical characteristics as the 6G5 and the 6H5, and differs from these tubes only in external bulb shape. Despite the difference in bulb shape it will generally be found that the 6T5 is interchangeable with the 6G5 and 6H5.

Certain uses of visual indicator tubes, such as, for example, the use of a visual indicator tube in a radio receiver having neither diode detection nor avc action, require that the shadow action operate in a manner just opposite to that normally obtained. This is sometimes considered objectionable in the case of the shaded sector type of visual indicator tube. Such objections are not raised when an annular ring type is used and these tubes may be considered ideal for such use.

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- The author particularly wishes to express his appreciation for the cooperation extended by R. M. Purinton, Raytheon Production Corp.



RCA 6AF6-G visual indicator tube, a typical dual indicator type.

imum avc voltage is produced, this being applied to the triode grid.

Now consider Fig. 10. The hot cathode (K) is emitting electrons in all directions and since the fluorescent target (T) is positive with respect to the cathode, the target draws these electrons to it. Since the target is coated with a fluorescent substance it becomes illuminated when subjected to this electron bombardment. Now, if the negative avc voltage were so high as to produce a complete triode plate current cut-off, the ray-control ring would be at exactly the same potential as the target since there would be no voltage drop in resistor (R), and consequently the whole target would be illuminated. Complete plate current cut-off is not entirely attained with the result that there is a small voltage drop in resistor (R). Consequently the ray-control ring is slightly negative with respect to the target, this resulting in an electrostatic field between target and ray-control ring of such nature that the electrons are slightly repelled from the