The

British Institution of Radio Engineers

THE AUGETRON AND ITS APPLICATIONS

by

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In the past we have shown various forms of the Augetron tube in its development, and we have now reached the stage at which this tube is being mass-produced and, therefore, is within the realm of ordinary mass-produced articles. Owing to war conditions and our development work, which is still in progress, it is impossible for me to discuss here all the possible applications of this new electron tube ; in any case, the time allowed is far too short.

We are, therefore, studying to-day mainly its performance in relation to ordinary wireless valves which we are going to use as a gauge of comparison, but I want to impress from the very start that the Augetron is not an ordinary wireless valve ; its technique of application is entirely different and does not run parallel to the technique of ordinary wireless valves. Let us, therefore, refresh our memory and study the function of an ordinary triode valve, as depicted in Fig. 1.

Here we have a cathode, a grid and an anode. In the anode circuit we have a load impedance Z. Voltage variations impressed on the grid will be repeated in the anode circuit by current variations, which in turn will give rise to voltage variations across the load Z. The voltage variation on the grid is the input voltage, and the voltage variation in the load circuit is the output

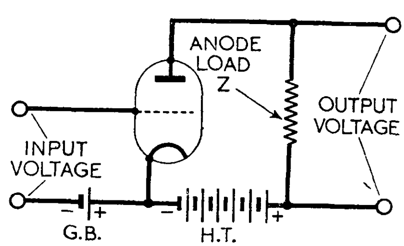

Fig. 1—*The simple circuit of an ordinary triode valve.*

voltage. The relation of grid volts to anode current is commonly known as the slope, and the amplification factor of wireless valves is the product of this slope by the impedance of the valve, which is expressed in the formula :

$$\mu = Ra \times gm$$

where Ra represents the valve impedance and gm the slope. The limitation of a wireless valve in its primary function, namely amplification, therefore, is limited by either of these factors, and by increasing either or both the amplification factor will be correspondingly increased.

Before going into the possibilities and methods of increasing this amplification factor, let us for one moment consider the actual limitation of the ordinary wireless valve. Assuming that we use maximum amplification, the actual limitation will be its signal to noise ratio, and by noise I mean noise produced by the valve itself. This noise generated in valves is of a threefold kind. First, the flicker noise ; secondly, shot noise ; and thirdly, space charge limited noise. Flicker noise is only of importance when frequencies below 1,000 c/s are used, and we can neglect it. Shot noise, however, is rather more general, and can be calculated by the normal shot formula giving for the mean square current :

$$\bar{I}^2 = 2eFI_c$$

I want to draw your attention to the factor I_c in this formula. It represents

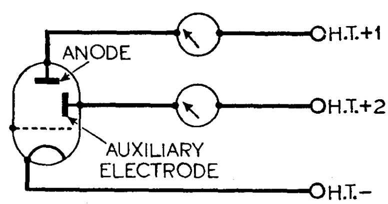

Fig. 2.—The simple triode with the addition of an auxiliary electrode.

total cathode emission and is a function of temperature and area as is shown in the empirical Richardson formula:

$$I = aT^{\frac{1}{2}}\epsilon^{-b/2T}$$

thus the larger the cathode area and/or the higher the temperature the greater will be the noise generated by the cathode.

The next thing is space charge limited noise, which is, of course, a function of frequency, but is mainly a function of anode current, and the larger the anode current the greater is the space charge limited noise. Thus, generated valve noise will at one moment, when maximum amplification is required, be equal to the signal noise applied to the grid, when no further amplification will be possible. Alternatively, in the case which is most common, the signal to noise ratio not being very high, the small variations of grid voltage repeated in the anode load circuit will contain a large component noise voltage, which becomes very troublesome when high amplifications are required.

Let us further consider the amplification factor on its own, and see whether it will be possible to increase this factor, and thus increase valve efficiency. Many attempts have been made in recent years to reach a solution by increasing the valve impedance, and thus the amplification factor, and high impedance valves, with a slope of about 8·5 milliamps per volt, which give a reasonable amplification factor, have been put on the market, but there are limitations in this direction.

If, in the case of the valve shown in Fig. 1, a device that would magnify the current changes could be interposed between the grid and the anode, the overall slope could be increased, and such a device is to be found in the phenomenon of secondary emission, on which I would now like to say a few words.

If we apply, say, 150 volts to the anode of the valve shown in Fig. 1, we will get steady emission, and a meter in the anode circuit would show a positive reading. If we now add an auxiliary electrode, as shown in Fig. 2, and we increase the anode voltage to 650V and we apply a potential of, say, 700 volts to the auxiliary electrode, we will find that the meter in the anode circuit will show a *negative* current, while the meter in the auxiliary electrode will have a positive current which is equal to the cathode current and the negative current shown in the anode circuit.

What has happened is that, under intense bombardment, electrons have been released from the anode surface and collected at the auxiliary electrode.

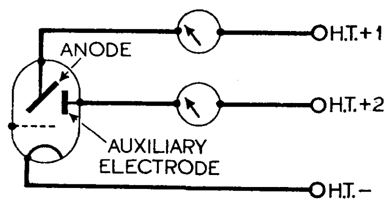

Fig. 3.—The secondary emission ratio is increased by setting the anode at an angle to the electron stream.

This phenomenon of releasing secondary electrons by a bombardment of high velocity primary electrons is known as secondary emission, and the number of secondary electrons released for every primary electron colliding is known as the secondary emission ratio. It should be observed that, if the anode is inclined, as shown in Fig. 3, the secondary emission ratio will be higher than in the case of Fig. 2, where the anode is perpendicular to the

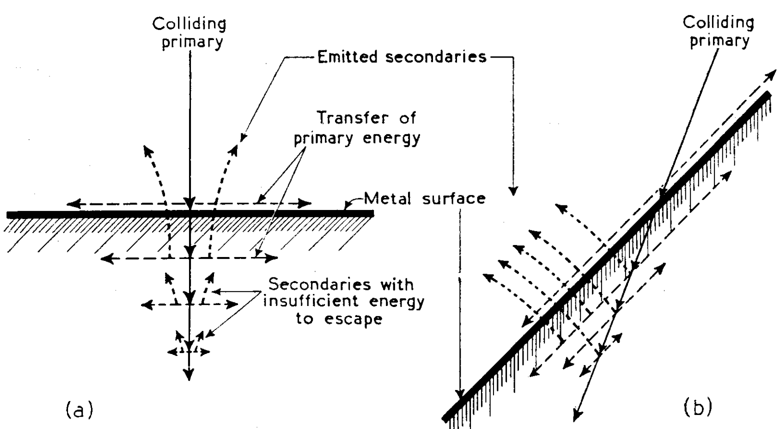

Fig. 4.—Diagrams illustrating the importance of the angle of impact. In (a) the emissive surface is perpendicular to the electron stream: penetration is deep, and secondaries are trapped. In (b) the angle is acute, and secondaries are released closer to the surface.

electron stream. Secondary emission ratio is a function, therefore, of angle. It is also a function of surface, and of velocity or, in other words, of voltage.

Let us take the third instance and analyse it first. When a primary electron hits a metal surface, kinetic energy is released in all directions, releasing secondary electrons which will emerge from the metal. If, therefore, individual electron energy is larger than the image force developed by the metal, it is quite easy to see that if the primary electron penetrates at an angle, as is shown in Fig. 4, the secondary emission ratio will be much larger because the electrons are all being released near the surface. The best angle lies between 30° and 60°.

Having thus covered the first and third instances there is only the question of surface. Alkaline metals constitute best secondary emitters, but it is not a criterion that, because a given surface is a good photo emitter, it also will be a good secondary emitter. The two phenomena are distinct from each other. The surface should be smooth when processed, and quite obviously, poisoning of the surface will bring the secondary emission ratio down. The poisoning can occur by air leakage or the production of gas inside the tube.

Early Secondary Emission Tubes

An example of an early attempt to apply the secondary emission principle to valves is seen in Fig. 5. Here we have a cathode surrounded by a control grid, an accelerator grid, an anode in a form of a mesh grid and a metal

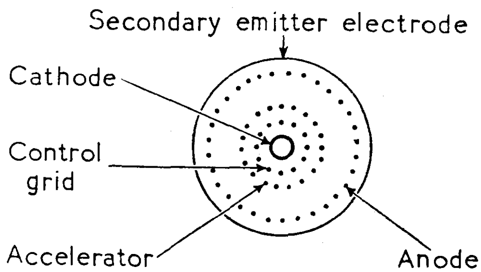

Fig. 5.—Arrangement of an early secondary multiplier.

cylinder which is the secondary emission target. The secondary emission coefficient of such a target is about 5 and the slope of such a valve is therefore multiplied by this coefficient, so that we have one stage of secondary emission which multiplies a slope by a certain factor. The drawback of this arrangement is that after 40 hours the secondary emission target is entirely covered with metallic barium which has evaporated from the cathode, and as the secondary emission coefficient of barium oxide is 4·87, while that of barium is only 0·83, it will be readily seen that after 40 hours the efficiency of such a device is less than unity.

In an attempt to overcome this difficulty, another single stage secondary emitter, commonly called " the target round the corner," was introduced. It is shown diagrammatically in Fig. 6. Here, the cathode is surrounded by a control grid and an accelerator ; at each end of the accelerator is a " V " shaped electrode ; a semi-circular electrode goes out from one of the V's, and at the end of this is placed the secondary emission target, while the anode is in the form of a mesh grid placed in front of the target. The electrons will follow a curved path before hitting the target, so that the evaporated metal barium, which travels in a straight line, will not strike the target. This, however, does not provide a complete solution, because although the slope is multiplied by the secondary emission coefficient, the signal to noise ratio has not been increased in the same ratio owing to the fact that the cathode is a normal valve cathode operating at normal temperature and having a fairly large area. It is not my desire to criticise this method ; it is quoted as a logical example of an attempt to arrive at the solution : a high amplification tube coupled with a high signal to noise ratio, which is what we require in the modern electron tube.

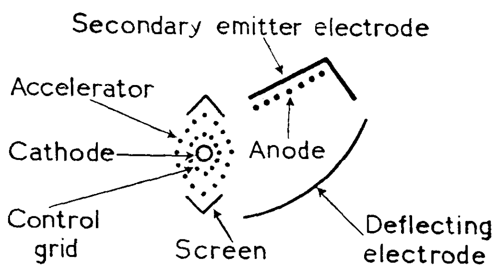

Fig. 6.—In order to avoid accumulating barium on the target, this is screened from the cathode, and the electron stream follows a curved path.

We are satisfied that we have found the solution to this requirement in the Augetron. Let us now consider for one moment the Augetron itself. It has a triode section which consists of a cathode, a grid and an anode with a centre opening, this opening being directed towards another section, in which the secondary emission stages are placed one behind the other. The triode section has been designed to have a slope ratio of 3 to 1, giving thus 3 milliamps per volt at 1 milliamp standing current. We generally use 10 microamps standing current, and we will have, therefore, a 30 microamps per volt change in the anode (which at the same time is the accelerator for the secondary emission portion). If now our secondary emission portion multiplies this current a thousand times, we should have a standing anode current of 10 milliamps at the final anode, giving thus a slope of 30 milliamps per volt.

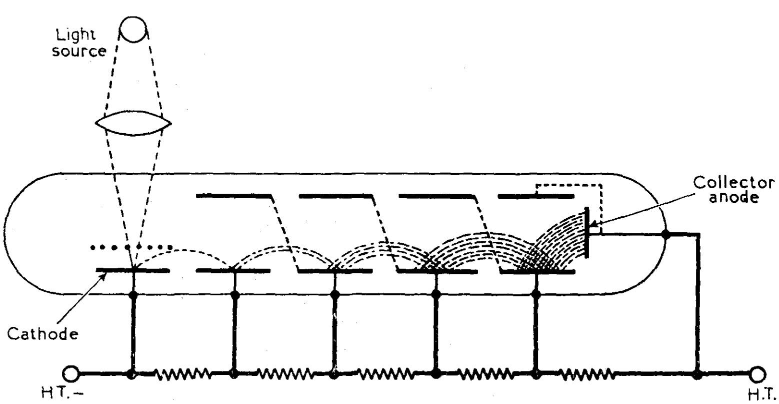

Fig. 7.—Diagram showing the electrode arrangement of the Zworykin electron multiplier.

One word has to be said about this secondary emission section in relation to prior development. You are all acquainted with Zworykin's development work on secondary emission tubes. His electrode arrangement, shown in Fig. 7, was derived from the Slepian type, where the electrons were directed by means of magnetic fields on to staggered electrodes. Note that in every case an angle of approximately 45° was being maintained. These secondary emission tubes were of the photo-electric type, and their maximum output was of ½ milliamp final anode current. A German by the name of Weiss used mesh grids placed behind one another perpendicular to the axis of the electron stream, and he used static focussing for keeping the centre. Again, in this case, the output was very small, and as in the previous solutions no overloading was possible without damaging the secondary emitting cathodes. This is inevitable in the case of mesh grids, because in order to prevent the primaries from going through it, the mesh must be fine, resulting in a rather fragile structure.

The Augetron Secondary Cathode

We have built secondary cathodes consisting of nickel plates in which conical impressions have been formed. The diameter of each diminishes in the direction of travel of the electrons. This results in a complete inclined surface being presented to the main electron stream, thus giving a maximum possible collision efficiency. To make sure of this maximum, successive secondary cathodes are staggered, and this is made possible by the construction of secondary cathode plates. The lugs with which the cathodes are supported on insulating pillars are eccentrically disposed in relation to the holes, so that all that is necessary in order to obtain perfect staggering is to turn the secondary

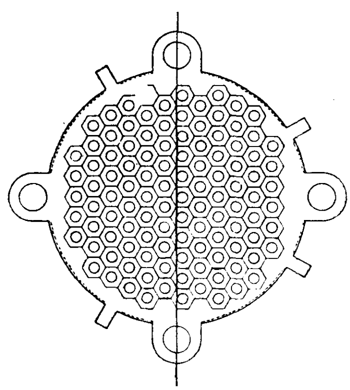

Fig. 8.—The Augetron secondary cathode. The perforations are off-set, as shown by the centre-line.

cathode plate 180° round with respect to the preceding secondary cathode. Fig. 8 gives a view of the secondary cathode.

The primary cathode, called the " Gun," consists of two ceramic plates in which are encased the cathode and the grid. This allows perfect location of grid *versus* cathode, ensuring a constant slope, while at the same time it prevents any stray emission from the heater wires from hitting the cathode.

There we have a complete picture of the Augetron secondary emission multiplier. There are, however, a few more details involving fundamental principles, which we have developed, that need elucidating in order to appreciate the operation of the Augetron. Fig. 9 (a) represents three secondary cathodes, m, n and z, of the type already described, which are maintained at a potential of 300 V, 600 V and 900 V respectively. When the primaries travelling from the direction P, after hitting the first secondary cathode m, arrive at the point O, they will be subjected to a positive field of 300 V of secondary cathode z and a negative field of secondary cathode m, so that a neutral zone exists round the secondary cathode area n. Therefore, only high velocity secondary electrons will have sufficient energy to pass through the neutral zone and be accelerated by the positive field of secondary cathode z

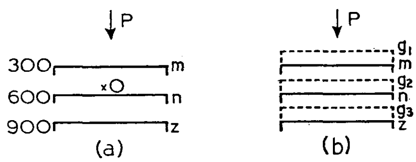

Fig. 9.—The electric field is neutralised by the addition of equipotential grids.

to their next target. Slow velocity secondary electrons will, therefore, return to secondary cathode n and thus diminish considerably the secondary emission coefficient of this particular target. If now we place grids in front of these three secondary cathodes, as shown in Fig. 9 (b), and connect these to their respective secondary cathodes, we will find that instead of the neutral zone having been created round secondary cathode n, by adding equipotential grid G2 an equipotential field has been created between this grid and a secondary cathode, abstracting the secondaries from the negative field created

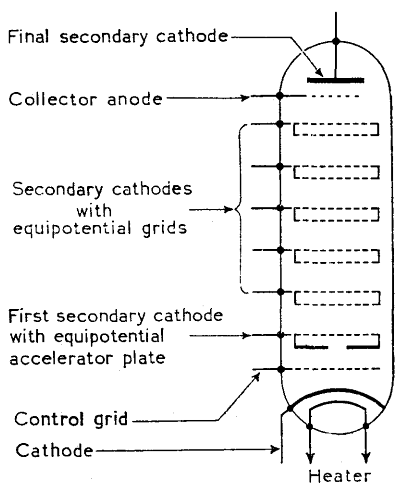

Fig. 10.—Explanatory diagram showing a complete five-stage Augetron multiplier.

by secondary cathode m, and allowing penetration of the succeeding field created by secondary cathode z extended to G3, this equipotential grid has the advantage of giving maximum possible multiplication of the secondary cathodes. The general arrangement of electrodes can be depicted as in Fig. 10, while in Fig. 11 appears an illustration of the actual equipotential grid plate.

Determination of Secondary Emission Factor

In order to determine the stage gain on the first secondary emission cathode, this is made 300 volts positive while employing the second cathode at 600 volts as a collector. If the meter of the first secondary emitter shows a negative current of 25 microamperes, while the current collected by the second cathode is 35 microamperes, then the secondary emission ratio would be the collector current divided by the current difference. In other words :

$$\frac{35}{35 - 25} = \frac{35}{10} = 3{\cdot}5$$

Another most important fundamental principle which we have developed concerns the loading of the equipotential grids. For voltage amplification it is desirable that the ratio of change of output current to control grid voltage should be as high as possible. If, therefore, we desire to increase this ratio we must look for other methods.

We have already pointed out that the final slope is dependent upon the product of the rate of change of output current with the primary current

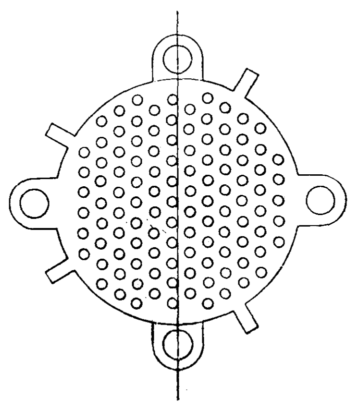

Fig. 11.—*The equipotential grid, with off-set perforations.*

and the rate of change of primary current with grid voltage, but if we want to increase this output slope, we must avoid an increase in standing anode current. This can be achieved by connecting the equipotential grid of one secondary cathode to the next succeeding secondary cathode and, as this secondary cathode is 300 volts above the secondary cathode to which the equipotential grid belongs, by connecting this through a load resistance having a high impedance over the frequency band to be amplified, this grid will be maintained at a positive potential above its secondary cathode. The resistance tends to maintain the amount of current absorbed at a constant value. Therefore, if the input current to the system is increased, no more current can be taken by this equipotential grid (connecting it here as an absorber grid), and consequently the output current has been increased by a greater factor. This would normally occur in the same way if the input current to the system were decreased considerably in order that the constant current to this equipotential grid may be maintained. In this manner, according to the characteristics required of the Augetron, absorption circuits may be fed to one, two or several equipotential grids. There is, however, a limit, because if too much current is absorbed, the quality of the output of the tube will suffer, as it will be difficult to maintain a large output current. A precaution which should not be neglected is the careful screening of the associated circuits to these absorber grids, and the higher the final slope required the more complete the screening must be in order to avoid oscillation. Fig. 12 shows the characteristic curve of a linear multiplier, while Fig. 13 shows the curve for a non-linear multiplier.

Photo-electric Augetron

In the photo Augetron, the primary emission is generated by a photo sensitive cathode which is housed in a structure similar in appearance to a top hat. This has a lateral opening to permit the light to be thrown on the cathode, and an opening at the bottom of the cathode to allow the primaries to go through to the first secondary stage. The secondary cathodes are the same as those in the thermionic Augetron, while equipotential grids are used and also loaded to divert the standing D.C. current in the same fashion as

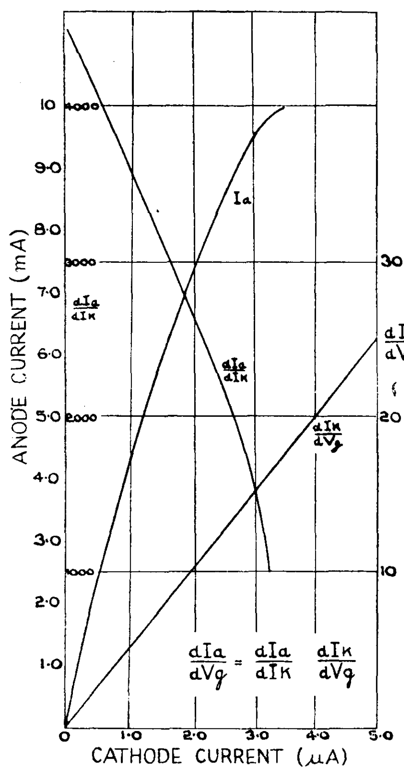

Fig. 12.—*Characteristic curves for a linear Augetron.*

explained previously. If, when the current is increased above a predetermined value, the current passing through the load resistance reduces the potential of the equipotential absorber grids to approximately zero, no more current can be absorbed ; any further increase in primary current is then faithfully reproduced in the output circuit. The amount of primary current flowing before appreciable output is obtained may be varied by adjusting the value of the load resistance in series with the absorber grids.

Applications : Photo-Augetrons

Let us now consider the application of the Augetron both photo-electric and thermionic.

When considering applications of Photo-Augetrons we should remember that they can be used in two different ways : firstly, they can be used as

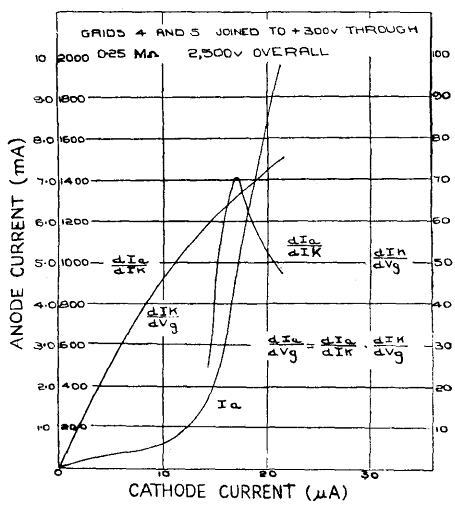

Fig. 13.—*Characteristic curves for a non-linear Augetron.*

ordinary secondary emission amplifiers ; and secondly, they can be used as secondary emission amplifiers, but with tuned or loaded equipotential absorber grids. I do not propose to enter into details as to all the possible applications to which the Photo-Augetron can be put—they are certainly too numerous and would require a work on their own, which is outside our present scope. I will now briefly describe one or two applications in order that they may serve as a guide to the further uses of the Photo-Augetron. Generally speaking, it is possible to replace a photo-cell and amplifier by a Photo-Augetron. Although this will not always be economical, it may be technically superior and therefore justified. An example of such an application is the substitution of a photo-cell and pre-amplifier in the sound-head of a talkie equipment.

Such a substitution will be a great improvement, as it will give a better reproduction at higher frequencies and a lower noise level, while the sturdiness of the secondary cathodes allows overloading without any damage to the cathode. On the other hand, Television transmission work or specialised work such as Spectro-photometry, Stellar-photometry, Colorimetry and similar investigations, can only be satisfactorily carried out by means of Photo-multipliers. Either of the standardised Augetrons will fulfil these requirements admirably. One such really special application is the Film gramophone. Many research workers have endeavoured to develop successfully an instrument of this kind without much success, because they have had

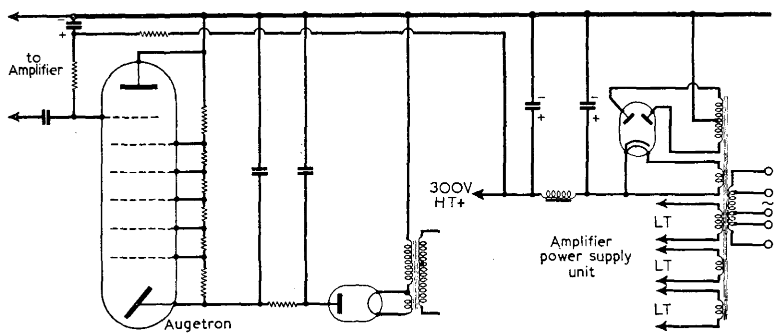

Fig. 14.—*Circuit arrangement of a Photo-Augetron used to precede a film gramophone amplifier. The thick horizontal line is H.T. negative of the amplifier, whose power supply is seen on the right.*

to overcome difficulties associated with both noise level and true frequency response, and in trying to solve one difficulty they usually amplified the other. The circuit given in Fig. 14 gives an illustration of how this might be achieved with the help of an Augetron without either of these difficulties.

We have so far considered Photo-Augetrons where the equipotential grids are tied and form an integral part of the secondary cathode. We will now consider how the equipotential grid in a Photo-Augetron can be operated independently and with advantage. Such a photo-multiplier may be employed

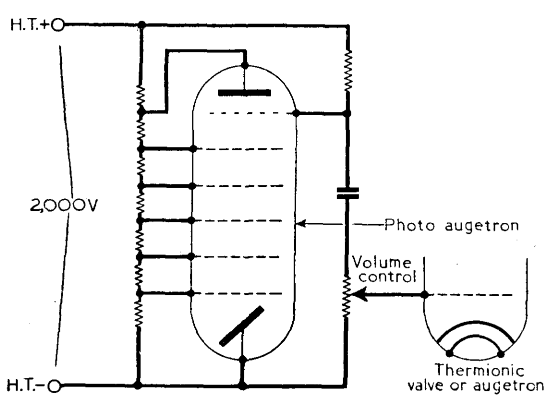

Fig. 15.—*Method of coupling a Photo-Augetron to a thermionic valve or Augetron. All resistances are* 1,000,000 Ω.

in circuits which are intended to operate relays from small amounts of light In such circuits the relay may be operated by the thermal emission from the cathode, or by stray light incident on the photo-cathode. It may be possible to adjust the multiplier so that this can only occur when the primary current.

exceeds a certain value. Where modulated light is to be received, a tuned circuit may be placed in series with the equipotential grid acting as current absorber, so that the multiplier is sensitive to light modulated at one frequency. Alternatively, loads having a low value to D.C., but high to a wide band of modulation may be employed. This will enable modulated light to be received whilst reducing the influence of any unmodulated light, such as daylight, from the circuit. These loads may be by-passed by series-tuned circuits to eliminate one particular frequency, for example, where interference is experienced from the light of lamps from an A.C. source of fixed frequency.

Where a larger amplification is required than that given by one Photo-Augetron, and it is desired to follow the Photo-Augetron by another amplifier, the coupling might give rise to some difficulties. The best method is that shown in Fig. 15. By employing two Augetrons in series, the first a Photo-Augetron and the second a thermionic, considerable gains can be achieved,

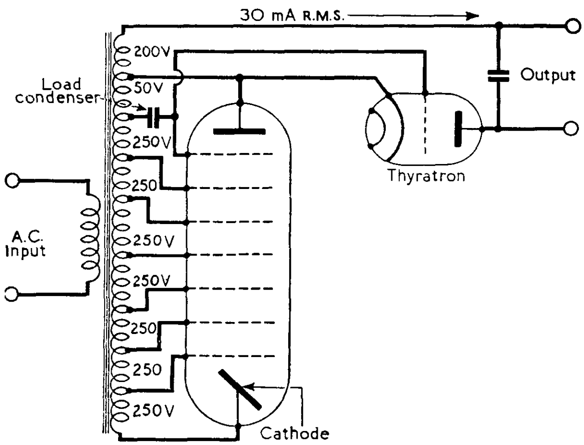

Fig. 16.—Photo-Augetron in association with a Thyratron to provide a large output. The power supply is entirely A.C

while at the same time the unwanted D.C. component of the Photo-Augetron is being eliminated and only the A.C. component passes on to the thermionic Augetron to be amplified.

It is best when using Augetrons to let them " run in " a few minutes before actually using them, as is done in the use of indirectly heated wireless valves. When using Photo-Augetrons with very small quantities of light, noise level at once becomes very important, and almost reaches the limit of amplification which it is possible to obtain in one particular circuit. This noise level may be decreased by eliminating as much as possible the " leakage " or " dark " current. This current, which is rather troublesome in secondary emission tubes, generally travels from the highest point of potential to the lowest. If we look at Fig. 10, showing the general arrangement of the electrodes in an Augetron, it will be seen that the last secondary cathode lies outside the path going from the cathode to the collector anode, and if we take the output from this secondary cathode and amplify it further by means of a thermionic amplifier, we will find a considerable reduction in noise level. The loss of signal is greatly compensated by the gain in diminution of noise level.

Fig. 16 gives another application of the Photo-Augetron which is rather interesting in that it is fed by an A.C. supply. This application is of particular interest when a larger current than the maximum allowable anode current is required. This is delivered by the Thyratron or grid-controlled gas discharge tube, the grid of which is controlled by the condenser in the anode of the Augetron. The size of this condenser will determine the sensitivity of the device, and if the value is too small, the whole device will become unstable.

Thermionic Augetrons

The application of the thermionic Augetrons must be considered for the two types of Thermionic Augetrons being manufactured. The first is the five-stage thermionic Augetron, specially suited for high frequency work, while the second is the six- or seven-stage thermionic Augetron, which is specially suited for either audio or intermediate frequencies.

Let us take the six- and seven-stage Augetron first. Its length of electron path makes it unsuitable for the amplification of frequencies higher than 50 Mc/s, but its mutual conductance up to that frequency will be about 40 milliamperes per volt. This type of tube is, however, of particular interest when used with equipotential grids which are loaded or tuned. For instance when this type of Augetron is wanted as a high gain audio frequency amplifier,

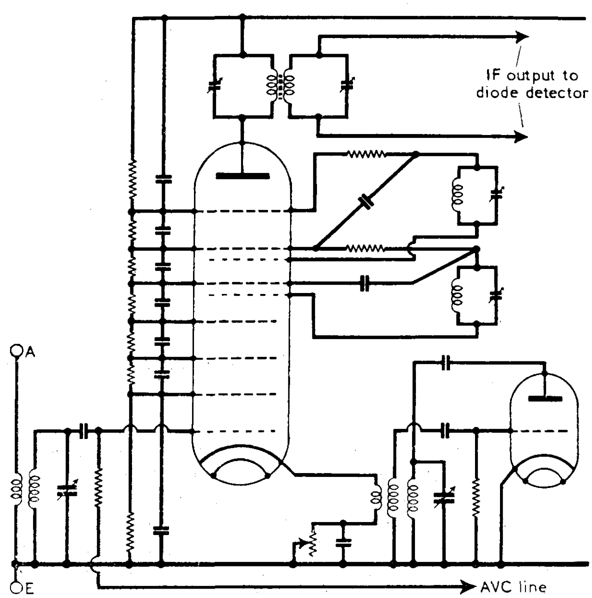

Fig. 17.—Application of the Augetron to a broadcast receiver. The I.F. output is fed directly to a double diode output pentode.

it is possible to load the grids so as to obtain a mutual conductance of 600 milliamperes per volt at 10 milliamperes anode current, or 60 milliamperes per volt at 1 milliampere per volt anode current.

This characteristic may be employed in the manufacture of a frequency changer or mixer tube. Current may be taken from the final secondary cathode circuit and fed back through a tuned network to an absorption plate in an earlier part of the multiplier, so that oscillations are generated. When a suitable signal is impressed on the control grid, a signal equal to the sum or difference of the two frequencies may be selected in the output circuit.

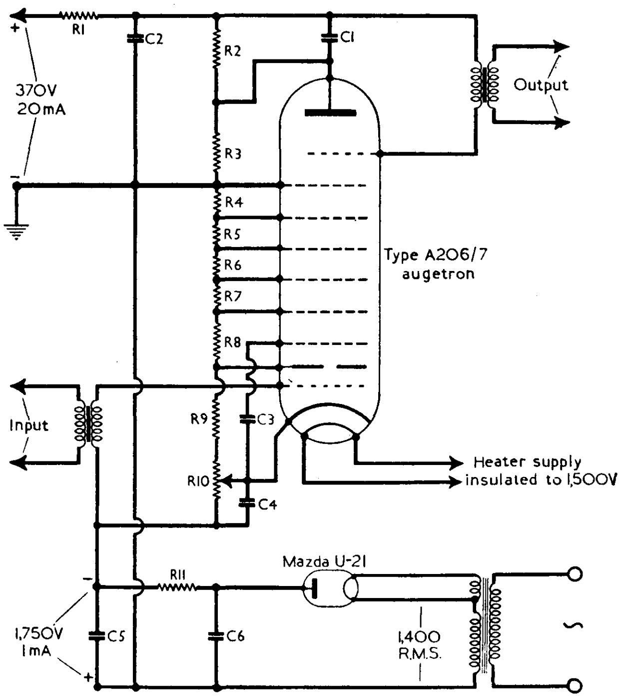

Fig. 18.—*Complete circuit diagram of the power supply to the Augetron. The input circuit is* 1,750 *V below earth potential, and hum may be troublesome.*

Alternatively, a separately generated oscillation may be introduced into the primary cathode or control grid circuit in addition to the signal frequencies. The absorption circuits may then be tuned to the sum or difference frequency which is required in the output, thereby increasing the sensitivity and selectivity of the device. Fig. 17 gives the circuit for this application. The I.F. output is fed to a double diode output pentode. The separate oscillator is shown on the right of the Augetron. It will also be seen that the secondary cathodes of the Augetron have been decoupled, while an extra decoupling condenser has been used between each loaded grid and its associated secondary cathode. One diode of the output valve is used to provide A.V.C. In building this experimental receiver we have used ordinary standard components, and it is beyond doubt that the efficiency will largely depend on the care with which these components are selected and/or designed.

Another application in which the Augetron is of particular interest is in the case of a short wave frequency modulation receiver. One five-stage Augetron is used as a pure H.F. stage, while a six stage Augetron acts as mixer and intermediate frequency amplifier, but has four additional grids tuned and loaded. In applications like these the advantages of the Augetron with loaded and tuned grids are very distinct, and they mark a new step in circuit technique. Undoubtedly very many applications are to be found for the Augetron with loaded grids, tuned and loaded grids or tuned grids, and they will certainly be extended when improvements are made upon the existing tubes.

The five-stage Augetron is specially suited where high frequency amplification is required. Its mutual conductance is not as high as the six or seven-stage because special attention has been paid to the time of transit in the tube, and the number of stages has been reduced to five. No appreciable drop in efficiency has been observed for frequencies up to 80 Mc/s, so that up to this frequency the Augetron is a high gain tube of outstanding and exceptional performances.

One last note on the use of Augetrons concerns a hum neutralising circuit. When using the power supply shown in Fig. 18, where two power

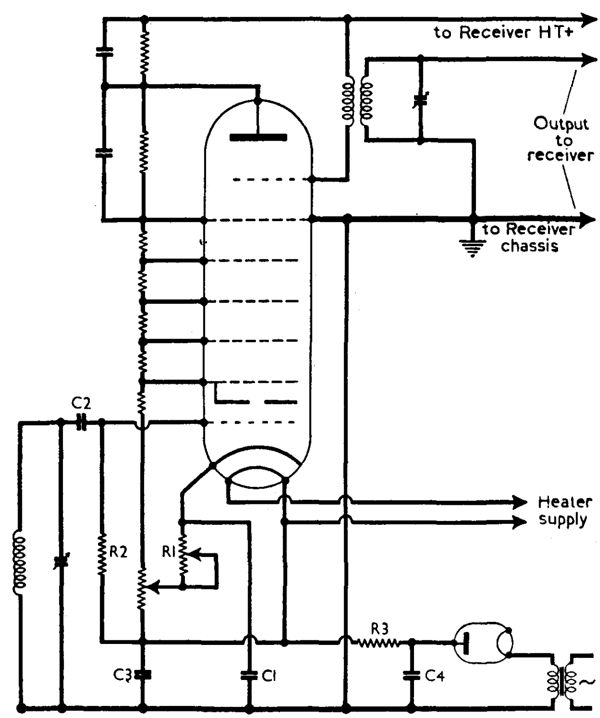

Fig. 19 (*a*).—*The cathode circuit is modified to neutralise hum voltages.*

supplies are connected in series, and the control grid of the tube is at a considerable voltage below the earth, any ripple on the high voltage supply is liable to be impressed between the grid and the cathode, if the grid is coupled to an output circuit at earth potential. To reduce the ripple voltage to a value small compared with the grid base of the Augetron would involve a complicated and expensive smoothing circuit. A typical amplifier circuit to balance out this ripple voltage is shown in Fig. 19 (a). The additional resistance R1 and capacity C1 are introduced so that the ripple entering the grid circuit through the coupling condenser C2 and the resistance R2 may be

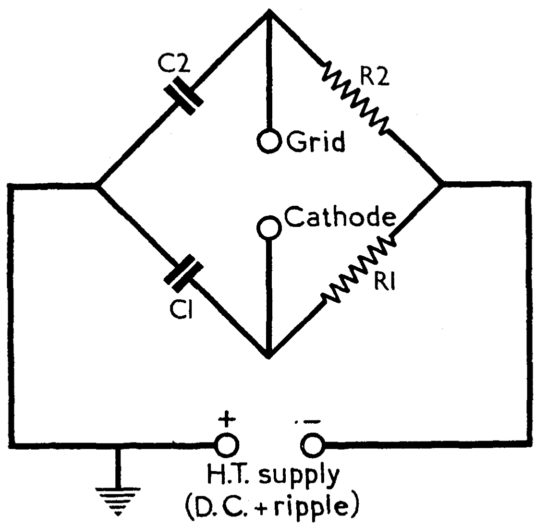

Fig. 19 (*b*).—*Equivalent grid-cathode circuit of Fig.* 19 (*a*) *in the form of a bridge to demonstrate ripple neutralisation.*

balanced out. R1 can be made variable in cases where a precise adjustment is required.

In Fig. 19 (b) the circuit has been redrawn in the more familiar form of an A.C. bridge. The introduction of a resistance in the cathode circuit also has a stabilising influence on the cathode current and is to be recommended on that account alone. When first using Augetrons and when not familiar with their technique, always put the grid bias at maximum and bring the high tension up slowly. This will avoid damage to the tube in the event of a wrong coupling of any of the circuit components.

CONCLUSION

At the conclusion of his address, Dr. Van den Bosch referred to the exhibits. He demonstrated on a test panel the comparative slopes obtained from Augetrons with and without loaded grids, and showed in operation a wireless receiver containing an Augetron. In another demonstration, a current meter was connected in the anode circuit of a Photo-Augetron, and he showed that no indication was obtained on the meter until a 100-watt lamp reached a critical distance from the tube.

Finally, he said, he wished to pay tribute to the loyalty of his assistants.

They were young, and he thought that they had a brilliant future before them. He hoped that his audience would remember their names :

D. Purser
T. Pattie
L. Barnes
J. Folkes
H. Ffennell
F. Charlton
V. Coleman

He then expressed his willingness to answer any questions, and the meeting was thrown open to discussion, which is recorded as follows :

Question.—You have not given us certain figures such as input impedance, output impedance, power output. What are they with the Augetron ? (Mr. Sowter.)

Answer.—We have measured the input impedance at 50 Mc/s and found it to be larger than 30,000 ohms. The output impedance is of the order of 150,000 ohms while the power output is 1 watt.

Question.—You told us there is a critical potential for secondary emission. Are the primary electrons absorbed in the metal if the potential is increased ?

Answer.—We assume that this is so.

Question.—I would be interested to know if the Augetron is affected by outside temperature changes ?

Answer.—Yes, but only to a small degree, and where Augetrons are used at the extreme range of amplification, temperature changes will influence thermal agitation and, therefore, to a certain extent, increase noise level.

Question.—Is the Augetron affected by outside illumination ? (Mr. Sargrove.)

Answer.—Yes, to a certain extent. The secondary cathodes are photo sensitive and therefore lamps lighted from the mains might induce a 50-cycle hum into the circuit. It is, therefore, advisable to shield the Augetrons when in use from outside illumination.

Question.—Is the response to the Photo-Augetron immediate ?

Answer.—Yes it is.

Question.—If it is possible to select certain frequencies, will it be possible to remove certain frequencies ?

Answer.—Yes. In one instance we advise the filtering of the mains frequency. Where Photo-Augetrons are used this, of course, is necessary.

Question.—Does the Augetron want warming up in the same way as an ordinary thermionic valve, or has it got a longer period or a shorter one ?

Answer.—It is about the same as an ordinary valve. If anything, it is slightly longer because of the settling down of the secondary cathodes.

Question.—Why does the frequency response fall off rapidly at the higher frequencies ?

Answer.—The mechanical dimensions of the Augetron are such that the frequency response is due to time of transit of electrons in the tube and not by degeneration in the cathode lead. You can, of course, increase the frequency response slightly by increasing the stage voltage, which will in turn shorten the time of transit.