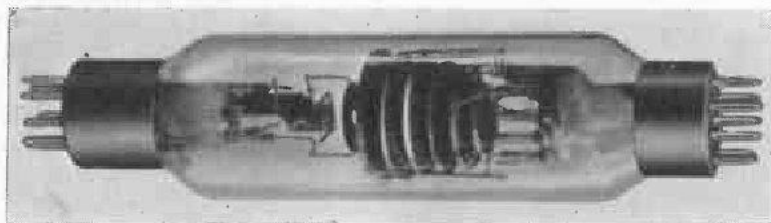


THE "AUGETRON"



MULTI-STAGE ELECTRON MULTIPLIER

IN certain respects the ordinary valve is far from being an ideal electrical device, particularly where either very small currents or very high frequencies are involved.

For example unwanted noise effects are inevitably produced in coupling resistances which set a limit to the smallness of the currents that it is possible to amplify.

The liberation of secondary electrons when surfaces are bombarded by electron streams has in the past been considered a troublesome effect, and in valve design special precautions are taken to reduce such secondary emission to a minimum. Now, however, it has been found possible to utilise secondary emission in such a way as to obtain very considerable amplification of currents over a very wide frequency range.

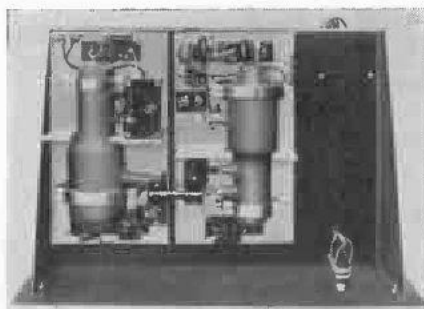
What the Secondary-Emission Tube is

The secondary emission multiplier tube, which is of comparatively recent development, consists essentially in a primary electron source, a suitable means of modulating the primary electron stream, one or more successive cathodes so treated as to produce copious secondary electrons when bombarded by that primary stream, and finally a collector electrode in the circuit of which may be placed the load in which the desired amplified output voltage will be developed. The primary cathode may be either photo-electric (in which case the incident light may be modulated) or it may be thermionic, in which case grid-modulation is employed, and voltage amplification becomes possible.

If the simplest case of electron source, secondary cathode and collector be first examined, some of the problems attendant upon the design of multipliers are at once apparent. It is necessary to devise an electron arrangement which allows as many

of the primary electrons as possible to bombard the second cathode, while providing at the same time on the secondary cathode surface, a suitable collecting field due to the final anode. But that collecting field must not be such that primaries are drawn directly on to the collector, otherwise the apparent ratio of secondaries to primaries will thereby be diminished.

Several methods of constructing multi-stage secondary emission multipliers are possible and of particular interest is the principle used in the Augetron. The cathode is in the form of a suitably sensitised metal plate, in which have been punched a large number of holes in funnel shaped depressions. In effect it may be said that when primary bombardment



Underside of vision chassis employing Augetron.

occurs at any point on the surface, the secondaries so liberated already possess a component of velocity in the direction at right angles to the main surface of the cathode. The collecting field due to the succeeding positive electrode can then penetrate through the holes at the bottom of each depression, and so the secondaries are drawn through and accelerated in the desired direction.

There are, however, certain other requirements which are to be met before an effective thermionic multiplier valve for voltage amplification purposes become possible.

The secondary cathode arrangement must be robust, but there will

obviously be an upper limit of current and voltage above which wattage dissipation can cause undesirable heating effects. These effects will be more pronounced at the output end of the tube and hence a robust, flat perforated plate is employed as the final collector anode. The maximum current that may be handled by this anode is of the order of 20 milli-amperes at 250 volts. Hence, if the standing D.C. output current is limited, obviously the D.C. input current must be limited also (it must, of course, be appreciated that an electron multiplier amplifies the direct current equally as well as the desired A.C. signal component). Therefore, the input end must function with a very small standing current. The Augetron multiplier is designed for the gain of about a thousand, and has an output current of 10 milliamperes, so at the input end, the current must be 10 micro-amperes, and the problem arises of constructing a cathode-grid arrangement which possesses a good mutual conductance for such a small current.

By careful design it has been proved possible to construct an electron gun in which the mutual conductance is some four times the standing current. This will then give (for the desired input current of 10 micro-amperes) an output slope of 40 milliamperes per volt at 10 milliamperes current, a figure 3 or 4 times better than the best radio valves on the market. The electrode arrangement at the gun end consists of a specially shaped indirectly heated thermionic cathode assembly in which the control grid and accelerator electrode are so situated as to project the modulated beam to the centre of the first secondary cathode. The thermionic cathode has a large emitting area in the equi-potential metal surround provided by a partially closed cylinder at cathode potential.

In order to obtain the overall gain of a thousand, a 6 stage multiplier has been standardised, running at an overall voltage of about 2,000 volts, or some 300 volts per stage. Under these conditions, each normal secondary emitter gives a stage gain of about $2\frac{1}{2}$. The final stage consists of a flat plate secondary emitter preceded by a flat perforated plate collector. This arrangement is found to give a gain equivalent to a multiplication by approximately 7. It has been found that the flat plate is preferable to an open mesh grid on account of wattage dissipation and rigidity.