The Shielded-Grid Tube At Last Arrives

Fourth Element, A Double-Screen Grid, Overcomes Troublesome Grid-to-Plate Capacity Effect: Amplification Factor Is 250

A NEW four-element amplifier tube, using a double screen-grid to shield the regular grid electrode, has just made its advent on the American market. It should be of great interest to all radio constructors and experimenters, because it possesses unusual characteristics that make it far superior to the ordinary three-element valve for radio-frequency amplification and because it represents what is probably the only real advancement in receiving-tube principles since the invention of the triode by Lee de Forest, in 1907.—EDITOR.

DURING the past twenty years, de Forest's three-element tube, which is directly responsible for the tremendous growth of radio in general and for the very existence of broadcasting itself, has been undergoing gradual improvement in mechanical construction and electrical efficiency; but, because its original filament-grid-plate arrangement has been faithfully retained, its fundamental principles of operation have not changed in the slightest. The addition of the fourth electrode has produced an entirely different tube of unique features, just as de Forest's addition of a grid between the filament and plate of the old Fleming valve created a device of radically different nature.

The *shielded-grid* tube (which may also be designated as a "shielded-plate" tube) opens a new and entrancing field in radio-frequency amplification, a field which the home experimenter as well as the laboratory engineer can explore for diversion, edification or profit. The technique of the tube is altogether different from that of its predecessor; it requires the use of special circuits designed to take advantage of its peculiar operating characteristics.

Although the new tube is a noteworthy development, it must not be expected to revolutionize the industry, or to render obsolete receiving sets of the types now in use. It does give greater radio-frequency amplification per tube than former types; but a certain number of tuned circuits must nevertheless be used, under present-day broadcast conditions, to obtain satisfactory selectivity.

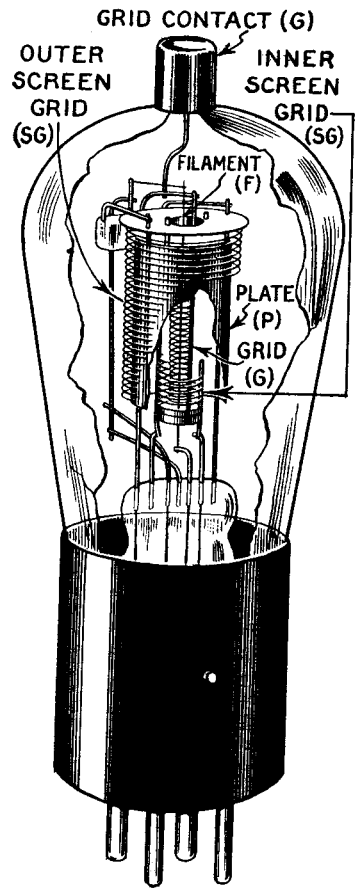
APPEARANCE OF THE TUBE

The shielded-grid tube greatly resembles, externally, one of the ordinary 201A type; it is of about the same diameter, but slightly longer. It is equipped with a standard four-prong UX base, the fifth connection being made to a small brass cap which is mounted on the top of the glass bulb. The glass appears to be partially silvered on the inside, as do most tubes because of certain chemical treatments which they undergo during evacuation.

The cut-away view of the tube, which appears on this page, shows very plainly the internal construction and the arrangement of the four elements. Starting at the very inside, we first observe a vertical filament, F, which is stretched taut by its supporting brace wires. Surrounding this filament is a spiral grid, G, about one eighth inch in diameter, and having a pitch of about a sixteenth of an inch. So far, the tube is identical with the standard triode. The ends of the filament are connected to the two heavy contact pins in the tube base, while the grid, which is the normal control-electrode, is connected to the upper brass cap on the glass.

THE FOURTH ELEMENT

The screen-grid is structurally double, consisting of two spirals of fine wire, SG. They are connected together, to act as one element, by a small metal disc which forms a sort of cap for the whole internal assembly. It will be noticed that the inner screen-grid (the turns of which are much closer together than those of the control-grid, G), is located between the latter grid and the inner surface of the cylindrical plate; while the outer screen surrounds the outer surface of the plate. The screen-grids, so named because of their obvious resemblance to screens, are connected to what is normally the grid pin on the tube base; the plate goes to the regular plate pin. The end view of the base shows these connections.



This cut-away drawing clearly shows the internal construction of the new shielded-grid tube.

The outer screen-grid shields the outer surface of the plate against the capacity effect of its surface in relation to the connecting wires in the tube.

ENORMOUS AMPLIFICATION

The shielded-grid tube is designed primarily for use as a radio-frequency amplifier in circuits designed to make use of its high voltage amplification and its low feed-back capacity between the plate and the inner (control) grid, G. When used for this purpose it is not interchangeable with general purpose three-element tubes, and cannot be used to replace them in standard receiving sets. It has a theoretical voltage-amplification factor of about 250, which makes possible an actual voltage amplification of about 20 to 30 per stage (depending on circuit losses), as compared with about 4 to 6 per stage, with ordinary three-element tubes.

The tube may be used also as a "space-charge" tube in audio circuits, and is useful for other experimental circuits in which a double-grid, four-element tube is required.

The filament of the new amplifier draws 0.132 ampere at 3.3 volts, making it equivalent in this respect to a tube of the 120 type. The plate voltage is 135; this is the recommended and the maximum value. When used in conjunction with storage-battery tubes of the 201A type, which have five-volt filaments, each shielded-grid tube should have a 15-*ohm resistor in series with its negative lead.* The resistor and filament may then be connected directly in parallel with the five-volt filaments of the other tubes and operated from the same rheostat. Of course this arrangement may easily be modified to suit other conditions of operation, as the only change necessary is in the value of the series resistor. In calculating rheostat resistance, it will be convenient to consider two shielded-grid tubes, with resistors, as drawing the same current as a 201A.

When the shielded-grid tube is used in dry-battery operated receivers, no filament resistor other than the customary rheostat is necessary, and its filament may be connected directly in parallel with filaments of the 3.0-3.3-volt type. In the calculation of rheostat resistance, the filament current may be considered equal to that drawn by two 199-type tubes.

WIRING CONNECTIONS

When used as a screen-grid radio-frequency amplifier the new tube is operated under the following conditions: plate voltage 135, connection through plate prong in base; the screen-grid (SG), 45-volt positive bias, through grid prong in base; the control grid (G), 1 to 1.5 volts negative bias with respect to the negative side of the filament, through metal top cap; filament, 3.3 volts. Neither plate nor screen-grid voltage is critical; the same bank of batteries may be used for both by merely taking off a 45-volt tap for the screen grid.

The bias for the control-grid may be obtained either from a separate 1.5-volt dry cell or from the voltage drop across a portion of the filament resistor when the tube is used on a six-volt "A" supply.

The internal shielding of the electrodes by the screen-grid makes neutralization of the plate-to-grid capacity unnecessary. However, every precaution must be taken to shield the control-grid circuit from other circuits. This is best accomplished by surrounding the grid coils, condensers and other grid-circuit components with metal shields. The shielding is further aided by keeping the lead from the control-grid (the wire running to the metal cap on the top of the tube) as short and as direct as possible; in some cases it may be necessary to surround the grid lead by a grounded metal sheath. Armored flexible cable, such as

(*Continued on page* 826)

The Shielded-Grid Tube

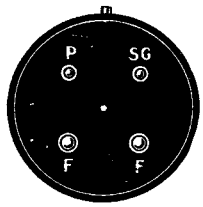
(*Continued from page 763*)

used for the wiring of ignition systems of automobiles, is excellent for the purpose.

When mounted in a vertical position (which is the best), the tube itself should be shielded by a metal jacket fitting closely over it but having an insulated hole at the top to allow the metal connecting cap to protrude. The shield or can should extend down at least to the base of the tube, and should be connected to either filament terminal of the socket.

OTHER ADAPTATIONS

Another use for the new shielded-grid tube will be found in circuits requiring a tube of high amplification factor and high mutual conductance, such as resistance, impedance- and transformer-coupled amplifier hook-ups. For this service the inner grid, G, is used as a space-charge



End view of the tube base, showing the arrangement of the contact pins. P, plate; FF, filament; SG, screen grid.

grid at a potential positive with respect to the filament. The operating conditions are as follows: plate voltage, 135 to 180, to be applied through a plate-coupling resistor of 100,000 to 250,000 ohms value; outer (screen) grid, 0 to 1.5 volts negative bias, furnished by rheostat or potentiometer; space-charge grid (inner), 22.5 volts positive bias, applied through metal cap; filament 3.3 volts. For this particular use the higher plate voltage is generally best.

In a subsequent issue, RADIO NEWS will present further data on these interesting new tubes, giving characteristic curves which the layman can understand and other information of value.