The A. C. Screen-Grid Pentode

The five-electrode tube which introduces revolutionary possibilities into radio circuit design, with data as to its characteristics, and suggestions as to circuits adapted for its employment

THE progress of tube development, which has been rapid during the past three years, made another spurt recently with the appearance of a new American "pentode," or "five-element" tube; which was demonstrated in this city to radio engineers late in January, and will, it was then stated, be available on the market about the time of the appearance of this issue of RADIO-CRAFT.

This tube (unlike the British pentode, which has been used as a power tube only, for the past two years) is designed especially as a radio-frequency amplifier, to work into a tuned-plate impedance; and is adapted also for audio-frequency amplification in suitable circuits. Its amplification factor, as may be seen from the technical data given below, is enormously high; rising to as much as 750, compared with the 420 of the '24 type, which it is intended to replace; while its mutual conductance may be as high as 2,500, compared with 1,050 for the '24. This operating characteristic is gained by operating with 250 volts on the plate, and 135 (positive) on the screen-grid; while the space-charge grid (the new element) carries 20 volts, positive.

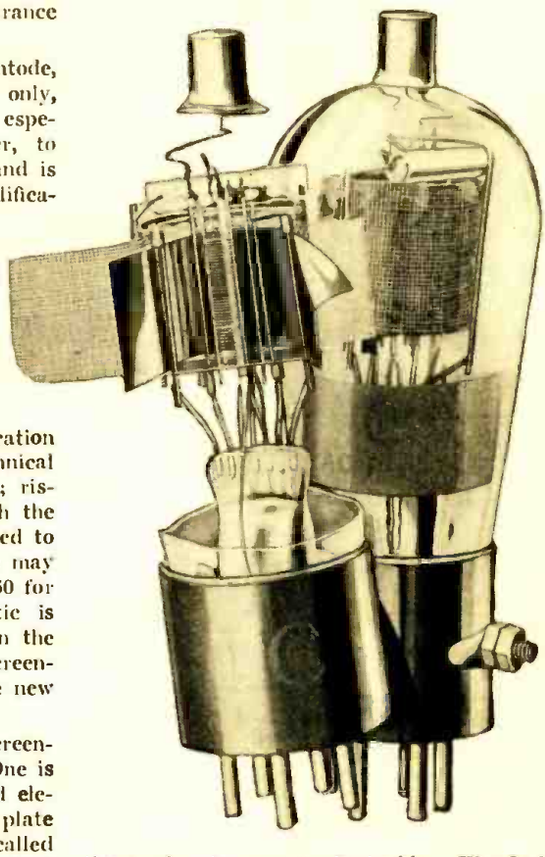

Fig. A

At the right, the new pentode, showing its external appearance. The connection to the additional, or "space-charge," grid is made through the binding post on the tube base. At the left, a pentode broken open to show its elements; the plate and screen-grid are spread out; the inner electrodes in their usual position.

It is well known that the older screen-grid tubes give two circuit options. One is that of using the fourth or screen-grid element as a capacity shield around the plate (from which fact the tube was often called a "shield-grid" type), while the inner grid serves the purpose of impressing the signal input on the tube. In the other connection, the inner grid is used with a positive charge to accelerate the flow of electrons from the filament and break up the negative "space charge" which surrounded it. This "space-charge" hook-up is preferred for audio amplification.

In the new pentode (styled the "P-1" by its manufacturer, the CeCo Mfg. Co.) both these advantages are obtainable. We find in the tube the following:

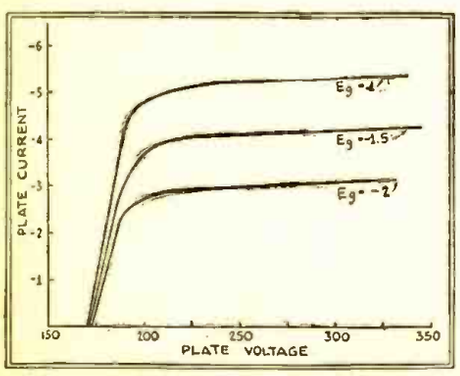

Fig. 2

Plate-current curves of the "P-1" pentode, showing the effect of different values of negative bias, applied to the middle or "control-grid," at different plate potentials.

The Five Electrodes

(1) A heater filament, similar to that of the '24 type, drawing 1.75 amperes at 2.5 volts. This is electrically isolated from the electrodes or elements of the tube, and connected to the "F" prongs of a UY-type tube base.

(2) An electron-emitter or cathode, heated by the filament as in the '24 and '27 tubes, and connected to the "C" prong of the tube.

(3) A "space-charge grid" surrounding the cathode. This is connected, not to the socket, but to a terminal at the side of the tube base. To this a source of low, positive potential is connected.

(4) A control-grid which, as in the '22 and '24 types, is connected to a metal cap at the top of the bulb. This, by means of a clip and lead, is connected to the signal input.

(5) A screen-grid which, as in previous tube types, is connected to the "G" prong of the tube base. Upon this is impressed a high positive voltage, somewhat lower than that of the plate. It serves the purpose of eliminating the capacitive effect between plate and control-grid.

(6) A plate, which is similar to that of the '24, and connected to the "P" prong of the tube.

The tube itself, a view of whose elements is given herewith, fits the standard UY tube socket; it is 1 13/16 inches in diameter, and 5¼ inches high.

A Pentode Circuit

The circuit diagram (Fig. 1) given here shows two pentodes used for R.F. amplification, following a band-pass filter; a third R.F. stage might follow, or the two stages feed into a standard detector.

The constants of the coils and tuning condensers are not given; this would depend upon the design of the receiver. (Articles dealing with band selectors have appeared, and will appear, in RADIO-CRAFT from time to time.) The cathode resistors R1, producing the control-grid bias, should be 150 to 160 ohms; the screen-grid resistors R2, 5,000 ohms; and the potentiometer R3, regulating the voltage on these elements and thereby serving as a volume control, 25,000 ohms. The by-pass condensers C1 (for space-charge grid), C2 (for screen-grid), C3 (for plate), and C4 (for cathode) may be of the customary 1-mf. value each; it will be noted that the common side of the unit shown is the cathode, or neutral point of the tube, and not the ground. The R.F. chokes L1 are also of standard value. With the high degree of amplification obtained by the pentode, the filter system shown is most essential.

Characteristics

In Fig. 2, we illustrate the effect of the various control-grid voltages upon the plate current. The screen-grid voltage used is 180 and the space-charge voltage 10. Irrespective of the control-grid bias, it will be seen, the plate-current curve rises abruptly with the plate voltage until the latter reaches about 180, and then flattens out.

The curve of the space-charge grid bias, which is not reproduced here, is practically a straight line, from 7 volts up, under standard operating conditions. While the increase of this positive grid voltage results in a higher mutual conductance reading, it produces at the same time also a higher plate current as well as a much higher grid current and it is therefore desirable to limit this voltage in the interests of longer tube life.

A comparison of the P-1 with the '24 type indicates a comparative R.F. gain 23 per

cent. higher for the pentode in each stage. This would amount to 51 per cent. more gain for two stages. With such amplification, it is obvious that precaution against grid overloading must be taken, especially in the detector. The characteristics of the tube, with a plate voltage of 250, and a control-grid voltage of 1.5 (negative) are as follows:

Space-Charge (volts +)....	10	20	10	20
Screen-Grid (volts +).....	180	180	135	135
Amplification Factor	575	540	740	750
Plate Resistance (thousands of ohms).....	285	180	380	300
Mutual Conductance (micromhos)	2000	3000	1930	2500
	Milliamperes			
Plate Current	4.1	6.0	1.7	2.6
Screen-Grid Current	0.8	0.9	0.5	0.2
Space-Charge Current	3.0	10.0	5.0	12.0

The D.C. Pentodes

In view of the non-technical publicity given the demonstration of the pentode, the Radio Manufacturers Association has issued a statement, conceding that "a given result is possible with less tubes, using pentodes," but arguing that "it is unlikely that the cost of a complete radio receiver would be any less. The pentode is used more widely in England, because of the greater popularity of battery-operated portable sets and because patent licenses are based on the number of tubes in the receiver. Reduction of tubes has therefore been more important in England, just as low-powered automobiles are more popular there on account of the license taxes being based upon horsepower."

The British pentode, as we have stated above, is a different type of tube, being a high-amplification power tube designed to work out of a low-voltage detector; just as we have here power detectors to work into a power tube without an intervening first audio stage. The Marconi "PT240," a typical pentode with two-volt filament (British and Continental tubes are standard at 2, 4 and 6 volts for storage battery operation) has a maximum plate voltage of 150, and a rated amplification factor of 100 with an impedance of 50,000 ohms (measured at 100 volts each on plate and screen-grid). It is used to give power output from a battery-operated set; while simpler tubes supplied with power from the house-current are not under such requirements of economy. It is possible however, that the power pentode will soon be introduced here.

EXPERIMENTERS will be rejoiced to know that, for the first time in many months, "something new in radio" has been developed.

The new tube, the Pentode, described in these columns, is revolutionary enough to be called new. It is true that in England, Pentodes have been used for some time; but they are of a different construction and used for an entirely different purpose (namely for audio-frequency output stages) never for radio-frequency.

Of importance is the fact that this new tube marks, probably, as great a revolution in radio as did the screen-grid a few years ago. Entirely new combinations and new radio circuits will be developed; and since the sensitivity of this tube is vastly greater than that of the screen-grid, fewer tubes will be required to accomplish the desired purpose.

We believe that the possibilities of the Pentode are greater than those of any previously-known amplifying tube.

The radio professional and Service Man will, of course, welcome the opportunity to familiarize himself with this new development, which will prove of considerable importance in commercial practice during the next few years.

As an interesting sidelight, it should be noted that (just as it did so many times before when a new and important radio item came along) the short-sighted radio trade at once "pooh-poohs" the Pentode, and begins to oppose it. Naturally, a new and important tube will scrap older developments; and such progress is never liked in certain quarters.

Such an important body as the Radio Manufacturers Association has taken great pains to send out warnings to the trade that the Pentode is not new and will not prove of value. We do not share this view; time will tell who is right.

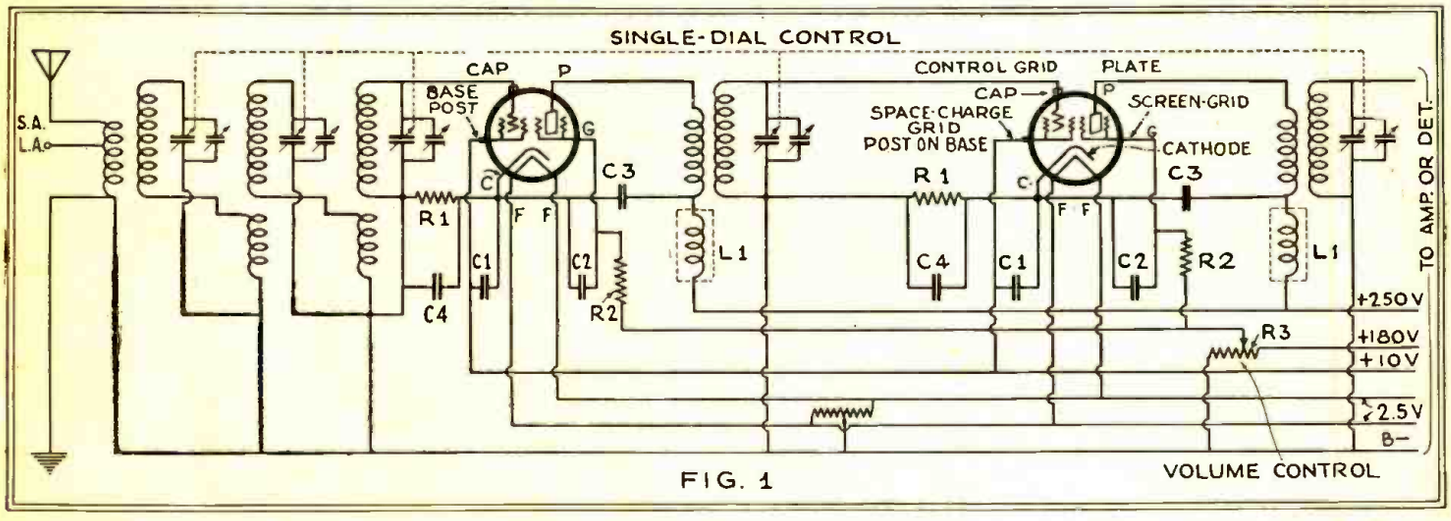

FIG. 1

A band-pass filter circuit, suggested by the makers of the pentode, for development of the tube's highest efficiency; the filter design is a special engineering problem, so constants are not given. As pentode circuits are developed for use, they will appear in later issues of RADIO-CRAFT.