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success to test samples 1 mm and 0.95 mm in diameter, and will operate with the same coils, although with lower sensitivity, on 0.56 mm wire. Other diameters would merely mean coil redesign.

Graphical Determination of Operating Point of Self-Biased Tube

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IN CHECKING vacuum tube circuits, the problem of finding the proper operating point on the static characteristic curve frequently arises. The circuit of Fig. 1 shows the data usually given: the supply voltage (E_{bb}) applied across the tube, a plate resistor (R), and a cathode resistor (R_k) in series.

The usual method of solution is one of successive approximations. First the load line corresponding to R (or $R + R_k$, if R_k is not negligible in comparison with R) is drawn on the plate characteristic chart. Then a guess is made at a likely plate current, and the voltage drop that this would produce across R_k is computed. Next, there is read from the load line the current which would result from a bias equal to the computed drop. The whole process is repeated several times until a current is obtained which differs only

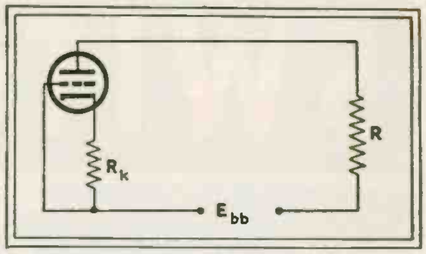

Fig. 1—Essentials of typical self-biased stage

slightly from the previous approximation.

If an error of several ma may be neglected, we might stop at the second current obtained (i.e., the first computed current), and take the mean of it and the initial guess. The error incurred will depend on the accuracy of the initial guess.

But, quite as expeditiously, we can obtain the true limit of the above process, and hence, the exact solution of the problem, by the following procedure for which an example is worked out in Fig. 2.

(1) Note the intersection of the load line with the zero-bias curve (A, Fig. 2) and mark the point A' vertically below it on the voltage axis.

(2) Choose a convenient plate current, I_o, (preferably less than that corresponding to A) and calculate the drop it would produce across R_k.

(3) Locate the point B, on the load line, which corresponds to a grid-bias equal to the drop just

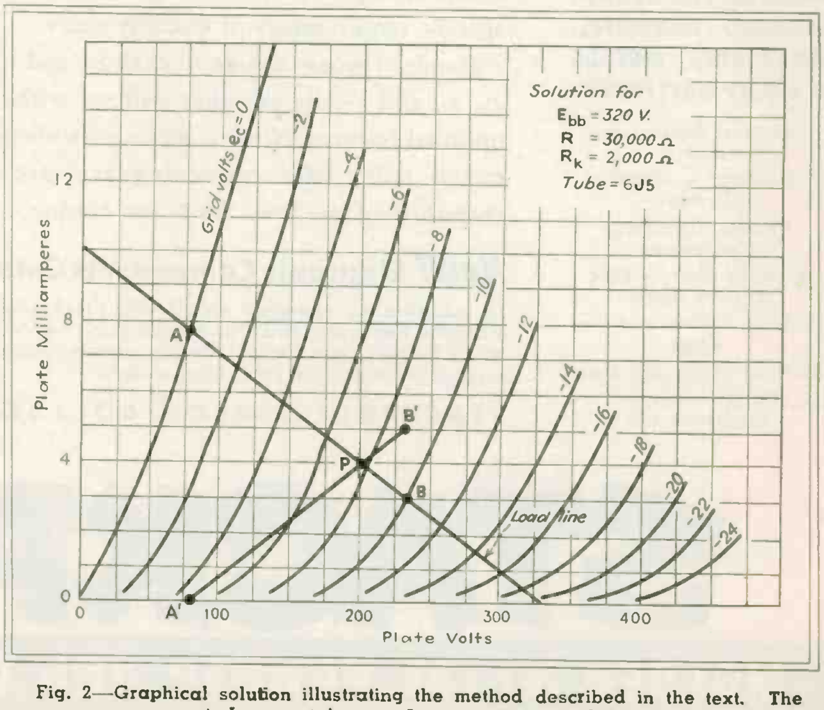

Fig. 2—Graphical solution illustrating the method described in the text. The current, I_{o1} was taken as 5 ma as suggested in step 2

calculated, and mark the point B' vertically above or below B on the horizontal line corresponding to the chosen current.

(4) Draw $A'B'$. Its intersection, P, with the load line is the required operating point.

If a constant bias is superimposed upon the self-bias, the method of solution is the same if we allow the grid-bias curve corresponding to the constant bias to play the same role as the zero-bias curve plays in the method as outlined above. That is to say, if the constant bias is e_o, the point A will then be the intersection of the load line with the bias curve for $e_c = e_o$.

The correctness of the method just described rests on the assumption that the constant-grid-bias curves, corresponding to equal increments of grid-bias voltage, cut the load line into equal segments. Within the limits of graphical accuracy, this assumption is nearly always justified.

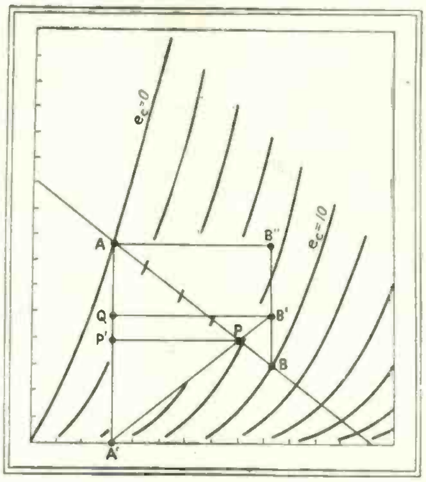

Fig. 3—A portion of Fig. 2 showing the geometrical relationship of the various points discussed in the text

Figure 3 is a repetition of part of Fig. 2 plus the points B'', P', and Q, whose geometrical relationship to the others is made clear in the figure. Now, if I_o is the plate current chosen in step 2, then the current corresponding to P will be

$$\frac{A'P'}{A'Q} I_o$$

In virtue of the similarity of triangles $A'P'P$ and $A'QB'$ this is equal to

$$\frac{P'P}{QB'} I_o$$

and this would produce in R_k a drop equal to

$$\frac{P'P}{QB'} I_o R_k \qquad (1)$$

But, by construction, the bias corresponding to B is $I_o R_k$. Hence, because of the above-mentioned assumption, the bias corresponding to P is

$$\frac{AP}{AB} I_o R_k$$

which, in virtue of the similarity of triangles $AP'P$ and $AB''B$ and because $AB'' = QB'$, is equal to

$$\frac{P'P}{QB'} I_o R_k, \qquad (2)$$

But the equality of (1) and (2) proves that P is the desired solution; i.e., that the plate current corresponding to P produces a drop in R_k equal to the grid-bias corresponding to P.

Geometric Solutions of L-Type Excitation Networks

By Robert C. Paine

The problem of feeding two or more resistive loads from a single source of power at varying currents and phase angles at a given frequency can be solved by the use of an L-type reactive network. One case in which this problem arises is in the excitation of directional antenna arrays. A chart for the solution of these problems has been shown by W. S. Duttera in the October 1942 issue of Electronics. In a specific problem more accurate results can be obtained by graphic solutions on a sufficiently large scale. Such diagrams can also be used to check mathematical solutions based upon them.

The requirements of a given network can be indicated by the ratio of the current required in the load to the current that would flow if the load was directly connected to the source of voltage. This ratio can be expressed by the factor $K\phi$ of which K is the ratio of absolute values of current and ϕ is their relative phase angle.

The network shown in Fig. 1 is designed to change the current by the factor 7/6 (−60°). The graphical solution shown is constructed as follows: Draw the line OD equal to the load resistance R, to any convenient scale, and draw OB equal to K times E at an angle of −60° Connect B to D and draw the line OC