A DEVICE FOR CHECKING THE DYNAMIC CHARACTERISTICS OF A MULTI-ELEMENT VACUUM TUBE

Walter C. Hunter, *Enid, Oklahoma*

As a result of the rapid developments in the field of multi-element tubes, many of the possible fields of application for them are relatively unexplored. If the optimum value is to be obtained from their use, a means of checking their dynamic characteristics and plotting a response curve must be placed at the disposal of the experimenter. It is the purpose of this paper to discuss the design of such a device, and report the results of its application in an investigation of the possible gain and attendant fidelity of one of the new tubes—namely the type 57 pentode. The method described is applicable to any portion of the frequency spectrum, but was used only in the audio range.

An audio oscillator of sinusoidal output, the frequency of which was dependent upon an external capacity, was used to feed a triod linear amplifier which in turn fed the stage to be tested. The oscillator was a type 30 tube arranged in unity-coupled hartly manner with a taped audio inductance. The oscillator and linear amplifier were battery powered and so designed that reasonable deterioration of the batteries would not materially affect the calibration. Calibration was accomplished by the method of comparison with a standard-pitch Baldwin grand piano. The accuracy of calibration is not critical; only the constancy is of paramount importance. The overall output of the oscillator and linear amplifier was studied by use of a cathode ray oscilloscope, and proved to be quite nearly sinusoidal, and constant in loop form regardless of frequency or output level.

A vaccum-tube voltmeter of novel design was developed. It was necessary that it be sensitive to potentials of a very low order and that all stray audio frequency due to ineffective detection be eliminated. To these ends a bridge circuit was used, the plate load of which was a resistance suitable to match the plate impedance of the tube. This load was by-passed with a small capacity to increase the effectiveness of the rectifier action. A vacuum-tube voltmeter is not linear and it was deemed wise to make all measurements in the same range to facilitate accuracy. For this reason a calibrated noninductive ratio bridge was used as the plate load of the stage under consideration.

If the grid matching and plate loading impedances be constant and their values known (by using resistance), the potential drop over them can be converted to a power ratio. It was desired to determine the gain within the stage in terms of decibels. The formula for the gain is

$$\text{D. B.} = 10 \log_{10}(\text{Power output} / \text{Power input}).$$

but power is equal to E^2/R; hence

$$\text{D. B.} = 20 \log_{10}(E_{out} / E_{in}) + 10 \log_{10} (R_g / R_p).$$

The potentials E are obtained with the vacuum-tube voltmeter. The known grid and plate resistances R_g and R_p, are constants; so the last term of the foregoing equation becomes a constant for any set-up and need be computed but once. In fact it only affects the placement in terms of D. B. and for purposes of gain comparison may be neglected.

We found that by departing from the conventional use of the screen grid when the tube is used as a pentode and applying a potential to it greater than that applied to the plate, by the plate load drop, a response curve resulted which was essentially flat, free from undesirable dips found in the conventional curve at about 600 cycles and indicative of a gain more than 10 per cent greater than that obtained by the conventional array. By departing from the conventional triode use of the tube so as to use the elements successively as control grids and plates in the order of their distance from the cathode, a response curve resulted which so far surpassed the curve of the conventional array as to suggest that a tube designed with a great number of grids used in that manner would be the answer to the search for an ideal amplifier tube. Not only is the response very flat, but the gain is greater than that due to the conventional triode, and the low-frequency rise is rapid, thus extending the useful portion of the audio spectrum to a new low level, an extension so necessary to true high-fidelity.