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DISCUSSION ON "HIGH AUDIO POWER FROM RELATIVELY SMALL TUBES"

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R. A. Heising[1]: This paper commends itself to a large part of the radio engineering field. It is of special importance to engineers concerned with the development of transmitters. The paper should be read by everyone who contemplates developing apparatus in which power efficiency of the radio equipment is important.

Push-pull amplifiers have been used in communication circuits for many years. They have usually been employed for reduction in distortion, or for providing a balanced circuit arrangement. Barton's paper emphasizes a long neglected use which results in increased output power, and decreased dissipated power simultaneously. This is accomplished by using a separate tube to amplify each half of the audio wave.

This circuit instantly commends itself to those interested in audio-frequency power at high power levels. The operation of loud speakers will probably occur to us as its widest field of application, but a very important field also exists in connection with radio transmitters. It is the latter application that I wish to discuss.

In transmitters employing plate circuit modulation of the power tubes, the over-all power efficiency is brought to a relatively low value by the power consumed in the modulators. By embodying push-pull modulator tubes, with a bias which is very close to the cut-off point, the power consumed in the modulators is almost eliminated during quiescent periods, while during talking periods the efficiency of the modulators is more than doubled. The improvement in efficiency in the modulators, therefore, has the very important effect of raising the plate circuit efficiency of the transmitter to a value double that of the next best system.

The importance of this is only appreciated by those who have tried developing transmitters to occupy small space. The improved efficiency in the modulating arrangement allows of using fewer tubes to give complete modulation. It cuts down the amount of heat liberated within the set. It allows of a considerable reduction in size of the power equipment. Modulator tubes are not subjected to as hard working conditions when operated at normal voltages, and have longer life. It is possible to operate the modulator tubes at voltages somewhat higher than normal without shortening the life.

At the same time, other important advantages result. The second harmonic, which is the largest frequency produced by distortion in most tube circuits, is largely reduced by the balanced arrangement, while the third and other odd harmonics which tend to add up are so much below the normal value of second harmonic that much improved quality is secured from tubes delivering large amounts of speech frequency energy. It is not difficult to construct this amplifier so that any distorting frequencies produced are 20 db below the fundamental. This is attested to by Barton's curves.

As a concrete example of increased audio power, and small distortion, I might mention the performance of the radio-telephone transmitter on the Levia-

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than. In this set two 212-D tubes (customarily rated as 250 watts capacity on 1500 volts) are used to modulate one 215-A tube (customarily rated at 1 kw at 3000 volts). All are operated at 2000 volts, at which the 215-A tube readily delivers 600 to 700 watts. In this case, complete modulation is secured without forcing the modulator tubes, and the distortion products when modulating 85 per cent are of the order of 25 db down from the fundamental.

The modulator tubes, though operating on a voltage one-third higher than normal, are not overworked in the least. Actually, a study of plate potential-space current relations existing over the audio cycle show that they are working less hard at all instants than when employed in a class A amplifier circuit at 1500 volts.

It is not to be inferred that the type of amplifier circuit under discussion may be arbitrarily substituted for other amplifiers or modulator arrangements in any transmitter. The amplifier possesses requirements of its own that react upon other parts of the equipment. These have been discussed by Barton probably for the first time.