SIMULTANEOUS PRODUCTION OF A FUNDAMENTAL AND A HARMONIC IN A TUBE GENERATOR*

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Methods are available for the transmission and reception of two or more frequencies from a single antenna. [1] The published methods, however, contemplate independent modulation of the several frequencies and require a separate generating tube for each frequency. The method here described involves only a single tube. The application immediately in view was the simultaneous transmission of several standard frequencies; other applications are pointed out below. The work, which was done under the direction of Dr. J. H. Dellinger, was part of the standard frequency transmission program of the Bureau of Standards. The reader should understand clearly that the method is one of multiplex frequency transmission but not of multiplex signal transmission, since there is only a single modulation.

The experiments were made in June, 1924, to determine if it were practicable to operate a radio transmitting set on two or more arbitrarily chosen frequencies simultaneously.[1] The results obtained when operating on two entirely independent frequencies were not as satisfactory as desired, but very good results were obtained when operating on two frequencies, one of which was a harmonic of the other.

The circuit arrangement used is given in Fig. 1. It is similar to the usual "Hartley" circuit but has an additional tuned circuit (L_2C_2) in series with the main tuned circuit (L_1C_1). The antenna circuit is similarly arranged (L_3C_3). It was found that, when the tube was generating a fre-

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[1] See "Multiplex Radio Telegraphy and Telephony," by Ryan, Tolmie, and Bach. I. R. E., 8, p. 451; 1920.

* Received by the Editor July 19, 1926.

quency approximately $f_1 \frac{1}{2\pi} \sqrt{L_1 C_1}$ and the circuit $L_2 C_2$ were tuned to some harmonic of f_1 that harmonic hf_1 would be materially amplified. The strength of the harmonic could be readily controlled by varying the coupling between $L_1 C_1$ and $L_2 C_2$, this coupling being the portion of L_2 common to both circuits. If the antenna, whose reactance has been

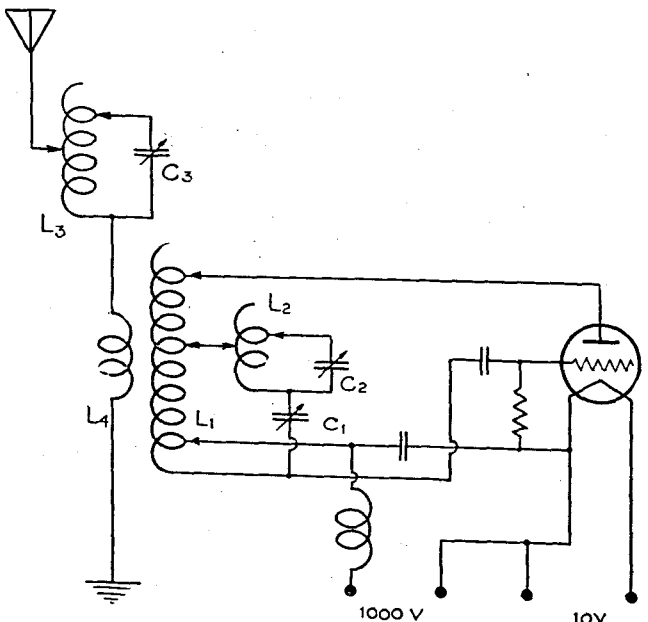

Figure 1—Arrangement for Producing Fundamental and One Harmonic.

adjusted [1] so that it is zero for the two frequencies f_1 and hf_1, is coupled to the inductance L_1 both frequencies are radiated.

Such a tube arrangement, operating on a fundamental frequency of 600 kilocycles with the third harmonic (1800 kc.) strengthened, was coupled to an antenna tuned to 600 and 1800 kc. Good transmission of both frequencies was obtained over short distances. The transmission was not tried over long distances, since a low power tube was used while making the experiments.

Harmonics as high as the tenth (500 kc.) were strengthened with this arrangement when working with a fundamental of 500 kc. Higher harmonics could not be obtained in this case as the limit of the second oscillatory circuit used

[1] See Bureau of Standards Circular No. 74, pp. 41 to 68.

was slightly over 5000 kc. With a fundamental 2500 kc., harmonics as high as the fifth (12,500 kc.) have been amplified, which was the highest frequency to which the oscillatory circuit used could be tuned. Higher harmonics could probably have been obtained if the oscillatory circuit could have been tuned to higher frequencies. It is to be understood that only one harmonic was amplified at a time. There was no apparent increase in the strength of the other harmonics.

It is evident that the operation of this circuit arrangement depends upon the feedback principle. By inserting the second *LC* circuit in series with the main tuned circuit and tuning the second *LC* circuit to a harmonic, that harmonic would be strengthened somewhat by virtue of the tuning. The then slightly increased harmonic voltage is fed back on the grid of the tube and is amplified, the strength to which the harmonic is amplified being dependent upon the coupling between the main circuit and the second *LC* circuit.

There are several important applications of this circuit arrangement. In relay broadcasting, the main station transmits the same program on two frequencies by means of two independent sets. One frequency is the regular operating frequency in the broadcasting band and the other a much higher frequency, usually between 2500 and 7500 kilocycles. With the circuit arrangement described here it would be quite possible to transmit two frequencies on the same set with any desired output within the capacity of the set on either frequency. This would result in considerable reduction in operating expenses as well as making an additional transmitting set unnecessary.

In calibrating a wavemeter by the use of generator harmonics a generating set of this type is useful when the wavemeter indicator is not sufficiently sensitive to respond to the weak harmonics of the usual generating set. With a fundamental frequency within the range of the wavemeter, any harmonic or higher frequency can be simultaneously obtained with a strength sufficient to operate the wavemeter directly. By changing the fundamental frequency somewhat a new harmonic will be obtained and an indefinite number of points thus secured. To obtain lower frequencies the generating set is adjusted so that the harmonic amplified is within the range of the wavemeter and the fundamental will give the lower frequency.