May 21, 1935. H. O. ROOSENSTEIN 2,001,891

MODULATION

Filed May 5, 1932 2 Sheets-Sheet 1

Fig. 1

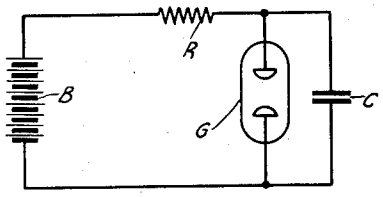


Fig. 2

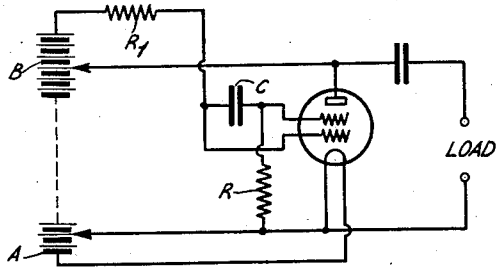


Fig. 3

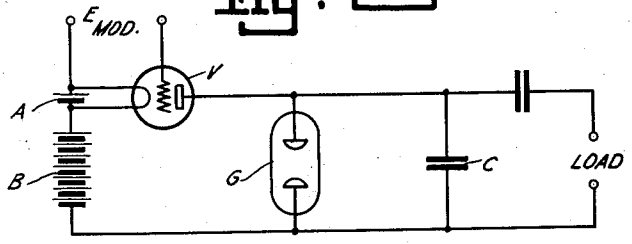
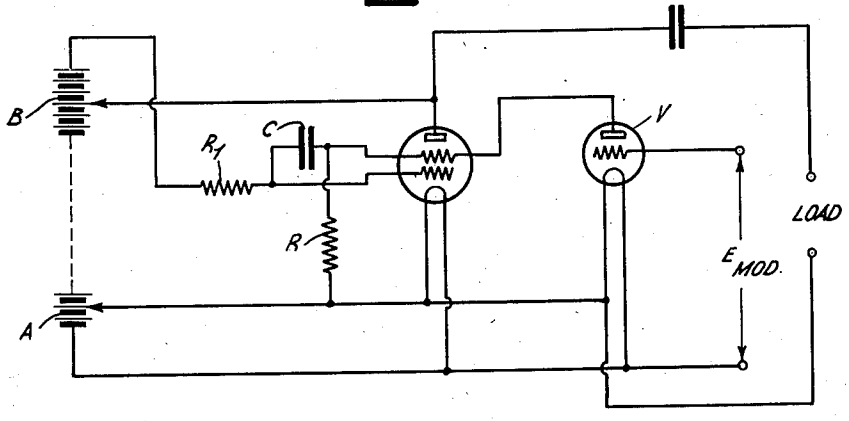


Fig. 4



INVENTOR
HANS O. ROOSENSTEIN
BY H. S. Snoden
ATTORNEY

May 21, 1935. H. O. ROOSENSTEIN 2,001,891

MODULATION

Filed May 5, 1932 2 Sheets-Sheet 2

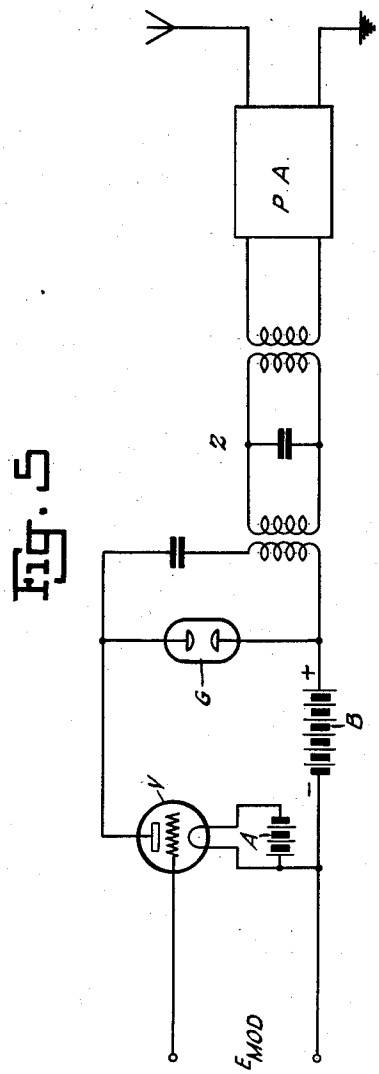


Fig. 5

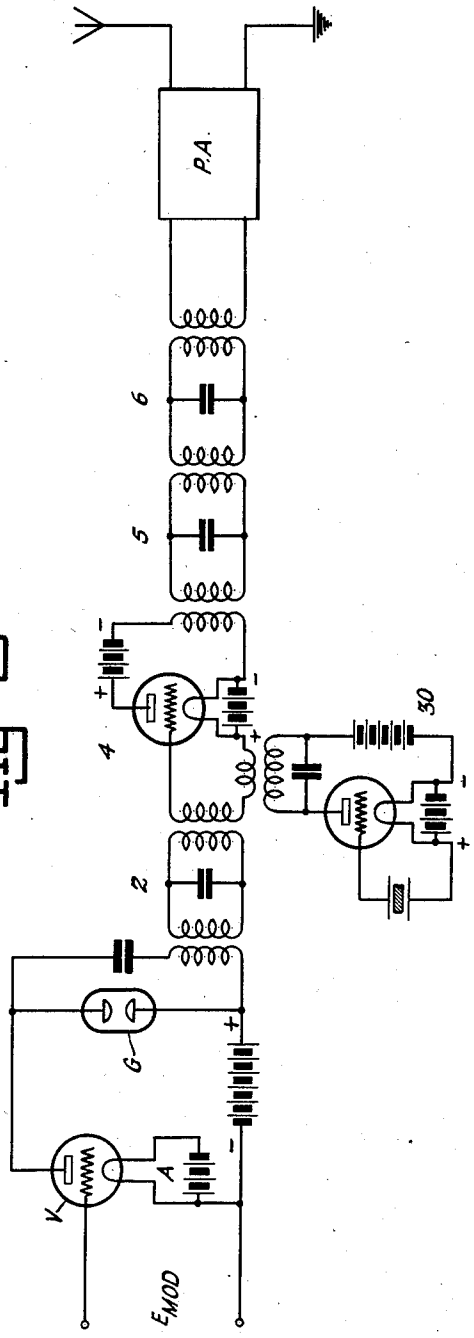


Fig 6

INVENTOR
HANS O. ROOSENSTEIN
BY H. G. Grover
ATTORNEY

Patented May 21, 1935 2,001,891

UNITED STATES PATENT OFFICE

2,001,891

MODULATION

Hans Otto Roosenstein, Berlin, Germany, assignor to Telefunken Gesellschaft für Drahtlose Telegraphie, m. b. H., Berlin, Germany, a corporation of Germany

Application May 5, 1932, Serial No. 609,422
In Germany May 21, 1931

3 Claims. (Cl. 179—171)

This invention relates to a method of and means for producing and utilizing frequency modulated waves.

In order to modulate the frequency of a valve transmitter as known in the prior art one of the frequency governing elements may be varied at the rhythm of the modulation. This element most preferably consists, in the case of a valve generator, of part of the capacity of the oscillation circuit. It is comparatively easy to design a condenser of this kind in such a way that, when driven by a motor, it will occasion a periodic alteration of the transmission frequency at the rate or rhythm of the rotations of said motor. However, arrangements of this sort fail to work when it is desired to change the transmission frequency at a very high rate of speed inasmuch as the speed of rotation of such a condenser can not be pushed very far. Also frequency modulation of a transmitter by voice is difficult because in this case a condenser must be used whose capacity, for instance, by varying the inter plate distance is to be varied in an inertialess manner at the rate and rhythm of voice frequencies. For this purpose could be employed, for instance, a two plate condenser. One of these plates consists of a steel diaphragm which is attracted by the magnetic field of an iron containing (iron cored) coil through which currents of voice frequency flow. The difficulty inherent in the construction of such a device resides in the low capacity variation that is attainable, and in the mechanical inertia of the system for response to the highest voice frequencies is hard to insure.

The object of the present invention is to provide an arrangement to overcome the above difficulties.

In describing the present invention reference will be made to the drawings, in which:

Figure 1 illustrates diagrammatically one manner in which frequency modulated waves may be produced and an arrangement for producing the same;

Figure 2 shows another arrangement for producing frequency modulated waves;

Figures 3, 5 and 6 show modifications of the arrangement of Figure 1; while,

Figure 4 shows a modification of the arrangement of Figure 2.

According to the present invention, therefore, the wave generator or oscillator whose frequency is to be modulatd is so designed that slight alterations of a resistance will result in relatively large variations in the frequency. This scheme is feasible, for instance, in a standard valve generator if the oscillation circuit which is to govern the frequency is given particularly high damping. It is also feasible to use generators whose frequency is a direct or linear function of the resistance. In this connection, referring to Fig. 1, suppose G is an oscillating gaseous-conduction lamp whose time of vibration is of the order of magnitude of the product T=R.C. Another generator whose frequency is governed in the main by a time constant is the multivibrator system Abraham and Bloch or else the multivibrator suggested by Van der Pol and Roosenstein. Such a multivibrator has been shown in Van der Pol, Patent No. 1,744,935.

In the generator arrangement shown in Fig. 2 oscillations are developed in the thermionic tube and circuits connected between the anode and inner grid and outer grid. The oscillation producing circuits include the condenser C, the resistance R, the battery B, etc., as shown. The frequency of the oscillations generated is governed by the size of the grid blocking condenser C and the leak resistance R. If in generators of this nature the frequency-governing resistance is replaced by an amplifier tube, as shown, for example, in Fig. 3, where the resistance R of Fig. 1 is replaced by the impedance of tube V or bridged by an amplifier tube as shown in Figure 4, where the resistance R of Fig. 2 is bridged by the impedance of tube V, and if the grid of this amplifier tube is energized by voice frequencies, then the frequency of the generator will be modulated approximately proportionally to the variations of the tube resistance. Another merit of this arrangement is that the ensuing amplitude modulation is but slight. Generators of the kind here mentioned are mostly not in a position to produce very short waves. However the wave which is generated contains a large number of harmonics or overtones for which reason it is possible with this cicuit arrangement to obtain frequency modulated short waves. For example, an arrangement as shown in Fig. 5 may be utilized. In this arrangement, the oscillation generator and frequency modulator may be as disclosed in Fig. 3. Here, however, a harmonic or overtone of the frequency modulated oscillations is separated out by a filter circuit 2 and supplied to a power amplifier PA, in which the amplitude of the overtone may be raised the desired amount. The amplified frequency modulated overtone may be utilized in any manner. For example, the power amplifier may feed the amplified frequency modulated overtone to an aerial system for radiation as shown. To be sure, the circumstance that the

frequency of the generators is easily variable by small resistances may turn out to be a disadvantage seeing that slight variations in the tube data, such as filament potential and plate potential are able to alter the frequency to a comparatively large extent. In order that these changes may not become so noticeable the wave of the generator is suitably modulated upon a generator of extremely constant frequency, such as a crystal controlled generator valve, with one of the two side-bands being used for the transmission.

An arrangement as briefly described above has been illustrated in Figure 6. In the arrangement of Figure 6 an oscillation generator and frequency modulator as disclosed in Figure 3 is utilized to supply an overtone by way of filter 2 to a modulator stage 4. The filter 2 may be tuned to the fundamental or an overtone of the oscillations generated and frequency modulated in the preceding circuit. The filter 2 supplies the fundamental or overtone to the modulator 4, which is also coupled to an oscillation generator 3 which may be of any type but is preferably of the crystal controlled type as shown. The output circuit of tube 4 therefore contains complex currents principally consisting of the frequency of the quartz controlled oscillator 3 and the two side bands which are spaced a definite distance apart on each side of the frequency of the quartz crystal oscillator 3, the distance apart being equal to the width of transmission of the frequency of filter 2. In order to insure that, of these complex currents in the output circuit of stage 4, only one of the two frequency modulated side bands may be sent out, the stage 4 is followed by band pass filters 5 and 6. The band pass filter 6 supplies the selected side band to a load circuit by way of a power amplifier PA. The frequency modulated waves may be supplied from the generator and modulator to any work circuit as shown.

I claim:

1. Means for producing high frequency oscillations and for modulating the frequency thereof at signal frequency comprising, a thermionic tube having an anode and a cathode, an inner grid and an outer grid, a source of potential and a resistance connected between said inner grid and said cathode, a resistance connected between said outer grid and said cathode, a capacity connected between said inner grid and said outer grid, a connection between a point on said source of potential and the anode of said tube, means for connecting a utilization circuit between the anode and cathode of said tube, a second thermionic tube having electrodes including, an anode, a cathode and a control grid, a connection between the anode of said last named tube and the outer grid of said first named tube, a connection between the cathode of said second named tube and the cathode of said first named tube, and means for applying modulating potentials between the control grid and cathode of said second named tube.

2. Means for producing undulatory electrical energy comprising, oscillation generating means including, a thermionic tube having anode, cathode, and a plurality of auxiliary electrodes, circuits for applying positive potentials between said anode and cathode and between one of said auxiliary electrodes and said cathode, frequency determining circuits connected between the auxiliary electrodes and the cathode of said tube, one of said circuits including a frequency determining capacity and a resistance in series, and means for modulating the frequency of the oscillations produced linearly at signal frequency including, a second resistance in parallel with said series resistance and capacity, a second thermionic tube having anode, cathode and control grid, a circuit connecting the anode to cathode impedance of said second thermionic tube in parallel with said second resistance, and circuits for applying modulating potentials between the control grid and cathode of said last-named tube.

3. Means for producing high frequency oscillations comprising, a thermionic tube having an anode and a cathode, an inner grid and an outer grid, circuits for applying positive potential between the anode and cathode of said tube and between one of said grids and the cathode of said tube, said circuits including a resistance connected between one of said grids and said cathode, and a resistance connected between the other of said grids and said cathode, a capacity between said inner grid and said outer grid, means for connecting a utilization circuit between the anode and cathode of said tube, whereby oscillations are produced in said tube and appear in said utilization circuit, and means for modulating the frequency of the oscillations produced linearly at signal frequency comprising, a second thermionic tube having an anode, a cathode, and a control grid, a connection between the anode of said last-named tube and a point on one of said resistances, a connection between the cathode of said last-named tube and a second point on said one of said resistances spaced with respect to said first-named point, and a circuit for applying modulating potentials between the control grid and cathode of said last-named tube.

HANS OTTO ROOSENSTEIN.