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H. SHORE

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OSCILLATORY CIRCUITS

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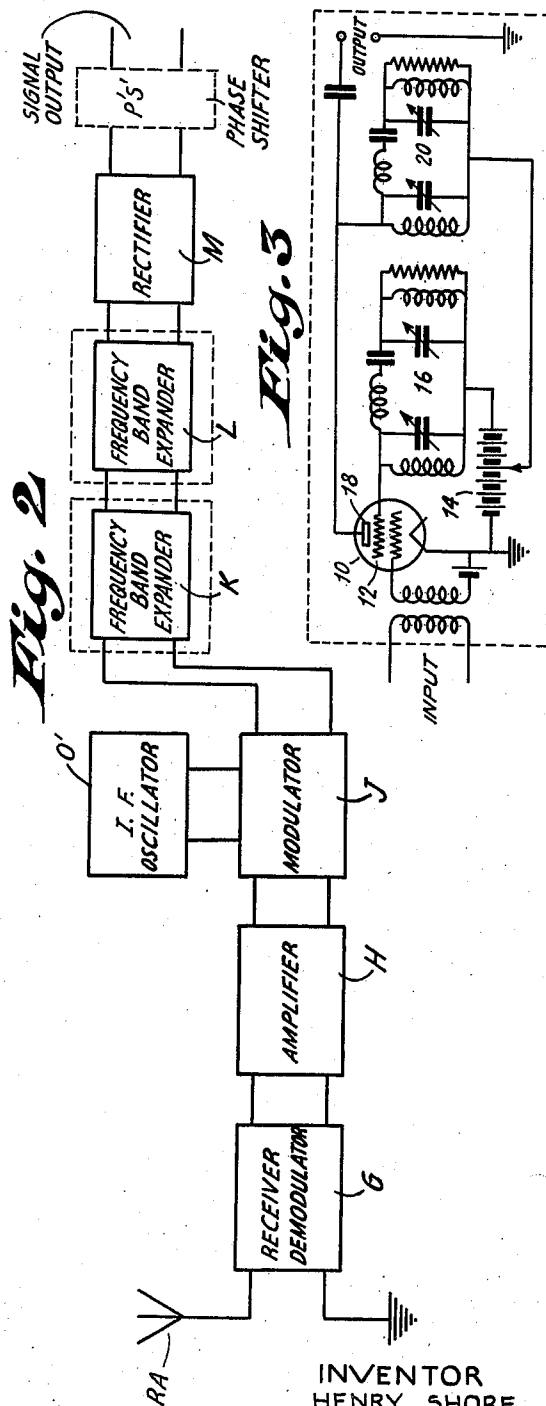
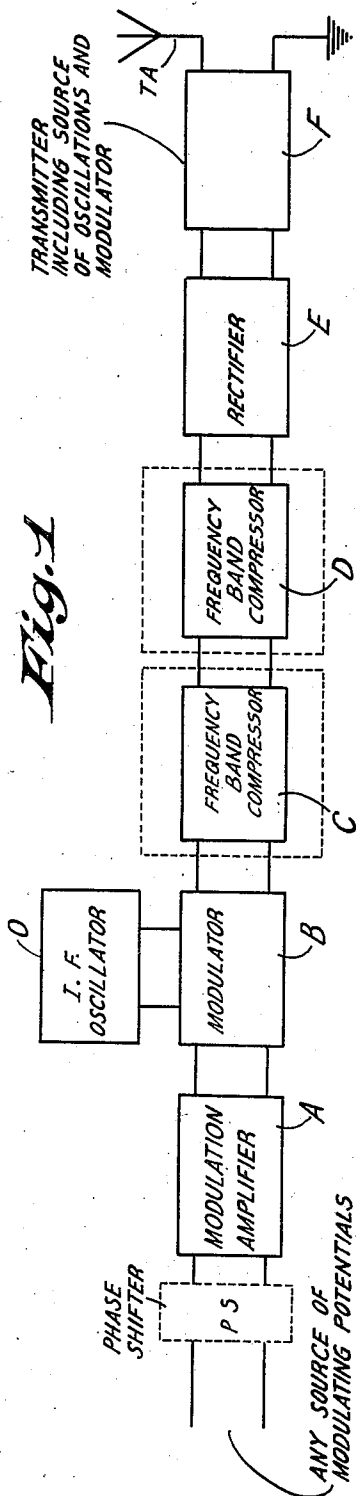
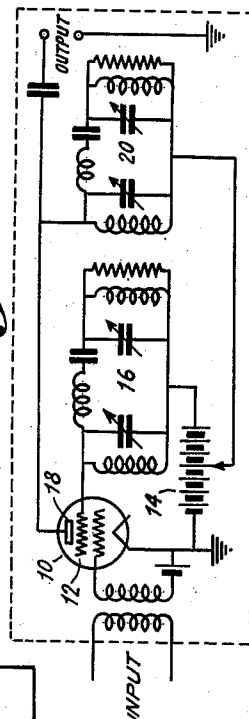


Fig. 3



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OSCILLATORY CIRCUITS

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10 Claims. (Cl. 178-44)

This invention relates to an improved method of and means for transmitting bands of frequency and in particular to a new method of and means for transmitting wide bands of frequency. The principle upon which this invention works is based on modulating an intermediate frequency by the desired frequencies and then compressing the resultant band of frequencies to a narrower band. This band is then rectified and the resultant signal is impressed on a transmitter in the usual manner for transmission. At the receiving end the compressed frequency band comprising the signal is expanded back to its former range of frequency and then utilized in any desired manner.

The present invention is of wide interest in the radio art since it is desirable in many cases that the frequency band worked with be of narrow width. For example, in signalling by code or by telephony a single side band is used in some cases to narrow the frequency spectrum taken up by the transmitter. This side band may, in accordance with my invention, be further limited. In high speed code transmission and multiplex or multiplex channel transmission, or facsimile, it is of extreme importance that the signals on the various channels be limited in their frequency range as much as possible. The invention is, of course, of particular interest in television and facsimile where the modulating frequencies may cover an extremely wide frequency range.

Prior to this invention great difficulty has been entailed in transmitting wide band of frequencies such as are required for television. This is due in part to resonance phenomena of the various circuits in the transmitting equipment and in the transmission lines or the transmission antenna. A further consideration is that due to the multiplicity of transmitting stations in use, the limited number of transmitting bands available are in many cases too narrow to permit transmission of signals which require a wide band of frequencies. This invention proposes by means disclosed below to eliminate this difficulty. In the case of television, for instance, where to transmit an image of suitable detail a frequency band of from zero to 250,000 cycles is required, transmission of said wide band is rendered simple by my invention. My invention will enable this range of frequencies to be compressed to say 5,000 cycles and thus this wide frequency range may be, after compression, transmitted over the ordinary broadcast and short wave transmitters in use today.

My invention is, of course, applicable to all

types of message signalling as well as to the sending of television and facsimile. For example, in telephony and telegraphy as known any means of reducing the width of the signal band for transmission over lines or through the air is exceedingly desirable. In addition my invention is applicable to secret signalling since although the signals may be received on any receiver, only receivers which include my novel features, including the frequency range expander, can with facility unscramble the signals. My invention, therefore, is of wide application in the art of communication. This is true whether all of the energy resulting from modulation is used or a selected part thereof.

The novel features of my invention have been pointed out with particularity in the claims appended hereto.

The nature of my invention and the manner in which the same is carried out will be understood from the following detailed description thereof and therefrom when read in connection with the drawing in which:

Figure 1 shows schematically a signalling device including frequency range compressing means, modulating means and signal transmitting means,

Figure 2 illustrates diagrammatically signal receiving means including frequency range expanding means and demodulating means; while,

Figure 3 illustrates details of the frequency band compressors and expanders used in the transmitter and the receiver of Figures 1 and 2, respectively.

In Figure 1, A represents a modulation frequency amplifier which may be connected to any source of modulating potentials. The modulating potentials from this source may cover a wide band of frequencies. The output of A is impressed on a modulator B which is also supplied by intermediate frequency oscillations from a generator O. All of the energy in the output of modulator B is impressed upon a frequency band compressor in C. The band of frequencies after compression in C may where desired be impressed on an additional frequency band compressor in D. Additional frequency band compressors may be connected in cascade with D if necessary. The compressed frequency band is then impressed on rectifier E and the output of rectifier E may be utilized to modulate a transmitting device including a source of oscillations. The modulated wave from the transmitting device may be radiated from an aerial TA or sent over transmission lines.

In Figure 2, G is a receiver responsive to the energy transmitted from TA and received on RA. The signal modulated energy is demodulated in G and amplified in H. The demodulated energy from H is impressed on a modulator J, which is in turn supplied by intermediate frequency oscillations from O'. The modulated intermediate frequency oscillations are impressed from J on to a frequency band expander K and from K on an additional frequency band expander L. The output of L is impressed on a rectifier M and from the rectifier the signals corresponding to the original signals at the source connected with A may be utilized in any desired manner.

In operation the signals from A modulate the intermediate frequency oscillations in B to produce a band of frequencies. This band of frequencies is then fed into the frequency band compressor in C. The frequency band compressor in C may be as illustrated in Figure 3 and may comprise a thermionic tube 10, having its control grid coupled as shown to the output of B. The additional grid 12 is connected to a source of potential 14 by way of a band pass filter 16, said band pass filter comprising parallel inductances and capacities and a resistance and series inductance and capacity element connected as shown, and responsive to a band width equal to that of the output of the modulated oscillator in B. The anode electrode 18 is also connected as shown to a point on the source 14 to apply a potential to the anode less than the potential applied to the electrode 12. The band pass filter 20 in the anode circuit may be as shown and may have a frequency range which bears the relation of

$$\frac{1}{N}$$

to the band pass filter in series with the grid 12. N is an integer 1, 2, 3, 4, 5, etc.

When the control grid is maintained negative by a biasing battery connected as shown and the anode is maintained at a positive potential less than the potential of the grid 12 a negative resistance characteristic will be obtained in the tube 10 and its associated circuits. If so operated, the tube 10 would generate oscillations of a frequency determined by the constants of the band-pass filter 20. Since a band-pass filter has impedance and phase angle suitable for oscillation at any frequency within its band-pass range, the frequency of the oscillation will be that in which the filter offers the optimum value of impedance and phase angle taken in conjunction with the rest of the circuit constants. Any slight change in constants external to the filter, such as plate voltage or grid excitation, will produce a change in frequency. In other words, it is a very unstable oscillator and its frequency can be readily controlled by the injection of a controlling frequency.

The energy appearing in the output of the modulator B is applied to the input circuit of the tube 10 and consequently acts as the source of control energy. Since in general, this source will be a complex aggregation of frequencies the oscillations in 20 will be confined to those frequencies within the pass band of 20. The filter 20 may be tuned to any harmonic or sub-harmonic of the range of frequencies impressed on the input circuit of the tube 10 and when so tuned will oscillate at said harmonics. By proper selection of circuit constants, the amplitude of the oscillations can be made to be proportional to those of the controlling frequency and, of course, will be held in step with the harmonic or sub-harmonic

frequency of the controlling source impressed on the input of tube 10. When filter elements are so related and tuned the relative phases of the currents and potentials flowing in the tube circuits will be such as to enhance the production of oscillations of the desired harmonic or sub-harmonic. By making the band-pass range of the filter 16, the same as that of the output of the modulator B, the degree of control of the frequency of the oscillations of the circuit 20 is enhanced and helps to eliminate any spurious frequencies which might be introduced by distortion caused by change of characteristics of the tube 10. Under a condition where it is desirable to operate the filter 20 on a harmonic or sub-harmonic range remote from the controlling frequency, the filter 16 should have a harmonic band-pass range intermediate between that of the input circuit of tube 10 and that of the filter 20 as this enhances the degree of control of the oscillations in the circuit 20. A circuit somewhat similar to the circuit described above to be used for other purposes has been described in detail in Whitaker Patent No. 2,067,365 issued January 12, 1937.

The band of frequencies of compressed range may be applied from the filter circuit 20 by way of a coupling condenser to any additional circuit and is preferably applied to a second frequency band compressor in stage D. This compressor may be as illustrated in Figure 3 and a description thereof is thought unnecessary. It may be noted, however, that the band pass filter in the device in D in series with the auxiliary grid is preferably tuned to the same frequency range as that of the band pass filter in the anode circuit of the preceding frequency band compressor in stage C. The band-pass filter circuit in series with the anode of the second compressor stage tube in D has a range which is given by the relation

$$\frac{1}{M}$$

where M is an integer which may be equal to N or may have some other value. Additional frequency band compressors may be added where desired and the output of the final compressor may be rectified in E and the rectified energy components may be utilized in any well-known manner to modulate carrier wave oscillations for transmission. The compressed frequency range will now be of such a width that it can be readily handled and readily impressed by the usual known apparatus on carrier waves now used in the broadcast and short wave frequency bands. The transmitter feeds the energy to a transmission line or to a radiating system TA.

It will be seen that by my novel method and circuit arrangement the width of the band it is desired to transmit may be reduced by the factor equal to the product of N and M. Thus if N is 2 and M is 3, the band width has been reduced to

$$\frac{1}{2 \times 3}$$

or $\frac{1}{6}$ of its original value. Of course, additional compressors may be used to further reduce the band or the value of N and M may be increased to accomplish the same result in a lesser number of compressors.

At the receiving end the signal is detected in the receiver G. The detected signal energy will have a frequency band equal to the output of stage D of the transmitter. This frequency band is then impressed on the amplifier H and from the amplifier H on to a modulator J, which is also supplied with an intermediate frequency carrier

from O' to modulate the carrier in J. The modulation energy from J is then fed on to a pair of frequency band expanders K and L connected in series as shown. More expanders may be used if desired. The frequency band expanders may take the form of the circuits shown in Figure 3 which has already been described except as noted otherwise hereinafter. When the signals are to be expanded, however, the circuit 20 connected with the anode 18 of tube 10 may be tuned to a frequency band M times the frequency band of the energy in the output of the modulator, that is, the detected signal. For best results with respect to the phase relation of the associating currents and potentials in the circuits and on the electrodes of the tube 10 when used as an expander the band-pass filter 20 should be tuned to a frequency range N times the frequency band of the detected signal. The expanded frequency band energy from the anode circuit of the first expander stage is fed to the input circuit of the second expander stage in L. The anode circuit band-pass filter of this stage may be tuned to a frequency band range N times its screen grid filter frequency band range and N times the frequency of the energy impressed on the input of this stage. In other words the band pass filter in the anode circuit of this second stage is tuned to pass a frequency band equal to M times N times the signal in the output of the demodulator G at the receiver. The output of the final frequency band range expander is then impressed on a rectifier M and we have in the output thereof signals of a frequency range equal to the frequency range of the signals impressed on the amplifier A at the transmitter. During transmission, however, we have converted this extremely wide frequency band range to a narrow frequency band range which may be readily transmitted through the air or over wire lines.

As an example of the above, suppose it is desired to transmit a band width of 10,000 cycles. The signal is impressed on modulator B which modulates the intermediate frequency oscillations of 200 kilocycles. The output now occupies a band width of 190 to 210 kilocycles. This is fed to C which has its screen grid band-pass filter set to pass frequencies from 190 to 210 kilocycles. The plate load is also a band-pass filter, but since we wish to divide by two, its range of pass is from 95 to 105 kilocycles. The output of this stage is then fed to D. Here the screen grid band-pass range is set for 95 to 105 kilocycles while its plate filter is set for 31.67 to 35 kilocycles, since we wish to divide in this stage by three. The output of this stage is then rectified and gives as a result a frequency band of 1.67 kilocycles which is used to modulate the transmitter.

At the receiving end, the rectified signal has this same band width (1.67 kilocycles). This output of the rectifier G goes to a modulator J, which is supplied with oscillations from an intermediate frequency oscillator O', say of 33.33 kilocycles frequency. The modulated output of J has a band width of 31.67 kilocycles to 35.0 kilocycles. This energy is fed to a frequency band multiplier stage K which has in its screen grid circuit a filter with a band pass of 31.67 to 35 kilocycles. Since we wish to multiply by three in this stage, the plate circuit thereof includes a filter having a band pass of from 95 to 105 kilocycles. The output of this stage K feeds into a second frequency band multiplier L which is to multiply the band between 95 and 105 kilocycles by 2. In this stage the screen grid filter has a band-pass

of from 95 to 105 kilocycles while the plate filter has a band-pass of from 190 to 210 kilocycles. The output of this stage is rectified and the output then has a band width of from 0-10,000 cycles, or, in other words, the original band width. Note that in transmission the band width was only two times the compressed signal width, i. e., 2×1.67 or 3.33 kilocycles as compared to 20 kilocycles which it would have been if conventional transmission had been used. Again it represents considerable saving even over single side band transmission which would have required a band width of 10 kilocycles. Of course, the compressed signal can be used to modulate a single-side band transmitter as well and so effect even greater economy.

Where the phase relation of and between the various components of the complex signal to be compressed is important said signal may be passed through a phase shifter PS before it is impressed on the modulator B. The phase shifter may be of any type as long as it provides the desired correction of the overall phase characteristics to the signal.

If the complex signal wave in the output of the receiver does not truly represent the complex wave at the input of the transmitter the demodulated wave may be passed through a phase shifter P'S' at the receiver output.

The application of the present invention in the radio art is obviously unlimited. I have pointed out some applications thereof in the prior description and in the description as follows. It will be understood, however, that I do not limit my invention to the uses mentioned.

An obvious application of my frequency range compressor and expander system consists in rectifying the output of the final compressor at the transmitter and feeding this rectified signal into any converter, the output of which is to key a class C transmitter. At the receiver end the signal may be integrated as disclosed in Shore United States application No. 654,088, filed January 20, 1933, Patent No. 2,031,134 dated February 18, 1936, and the energy from the output of the integrator may then be fed into one or more cascaded stages of band frequency expanders as described hereinbefore, and thus expanded back to its original band width for utilization purposes.

It is, of course, apparent that radio transmitters need not be used but that the output of stage D might be placed on telephone lines or other transmission channels. This, of course, would be highly desirable for the transmission of television programs since by compressing the desired frequency band to within the limits of the telephone lines existing equipment and lines may be used over nation-wide net works.

The filter circuits in the auxiliary grid and anode circuits of the frequency expander and compressor may be as shown or may be modified in various respects without departing from the spirit of the present invention. In some cases the band pass filters may be of simpler structure, in other cases more complex filters may be necessary. All that is necessary in any case is that the filter be resonant over the desired band frequency.

Having thus described my invention and the operation thereof, what I claim is:

1. The combination with a source of signal oscillations which cover a considerable frequency spectrum, of an intermediate frequency oscillator and a modulator connected to said oscillator and to said source, a thermionic tube having a con-

trol grid circuit coupled to the output of said modulator, said tube having an anode, a cathode and an auxiliary electrode, a filter circuit responsive to a frequency band of considerable width but of less width than the frequency spectrum of the signal oscillations connected with the anode of said tube, said filter circuit being tuned to a mean frequency which is sub-harmonically related to the frequency of the energy in the output of said modulator, means for applying positive potentials to the anode of said tube, and means for maintaining said auxiliary electrode at a positive potential higher than the potential applied to said anode, whereby a negative resistance characteristic is obtained in said tube.

2. The combination with a source of signal oscillations which cover a considerable frequency spectrum, of an intermediate frequency oscillator and a modulator connected to said oscillator and to said source, a thermionic tube frequency band compressor having its input circuit coupled to said modulator and its output circuit including a filter receptive to a frequency spectrum of considerable width but of less width than the width of the frequency spectrum of the signal oscillations coupled to a rectifier, means for tuning said filter to a mean frequency which is sub-harmonically related to the frequency of the energy in the output of said modulator, and means to insure the production of oscillatory energy in said output circuit at said mean frequency when energy is transferred from said modulator to the input circuit of said tube.

3. In signalling apparatus the combination of a source of modulating potentials, a source of intermediate frequency oscillations, a modulator connected on the one hand with said source of modulating potentials and on the other hand with said source of intermediate frequency oscillations, a thermionic tube having its input electrode coupled to the output of said modulator, said tube having an auxiliary electrode and an anode, a circuit connecting said auxiliary electrode to a source of potential positive with respect to the cathode of said tube, a filter circuit connecting the anode of said tube to a positive source of potential which is less than the potential applied to said auxiliary electrode, and means for tuning said filter circuit to a frequency band, the mean frequency of which is a function of the frequency of the band of energy in the output of said modulator.

4. In signalling apparatus the combination of a source of modulating potentials, a source of intermediate frequency oscillations, a modulator connected on the one hand with said source of modulating potentials and on the other hand with said intermediate frequency oscillator, a thermionic tube having its input electrode coupled to the output of said modulator, said tube having an additional electrode and an anode, a band pass filter circuit connecting said additional electrode to a source of potential positive with respect to the cathode of said tube, means for tuning said band pass filter to a frequency band which is a function of the frequency band impressed on the input circuit of said tube, a filter circuit connecting the anode of said tube to a positive source of potential which is less than the potential applied to said additional electrode, means for tuning said first named filter circuit to a frequency band which is a function of the frequency band to which said first named

band pass filter circuit is tuned, and a rectifier coupled to said anode circuit.

5. Receiving means comprising in combination, a source of carrier frequency oscillations on which compressed signals have been interposed, an intermediate frequency oscillator, a modulator coupled on the one hand to said source of signals and on the other hand to said oscillator, a thermionic tube having its input electrodes coupled to the output of said modulator, said tube having an auxiliary electrode and an anode, a band pass filter circuit connecting the auxiliary electrode of said tube to a source of positive potential, means for tuning said band pass filter to a frequency which is a function of the frequency of the energy in the input of said tube, a band pass filter connecting the anode of said tube to a source of potential less positive than the potential to which said auxiliary electrode is connected, means for tuning said last named band pass filter to a frequency which is a function of the frequency to which said first named band pass filter is tuned, and a rectifier connected to the output circuit of said tube.

6. A translating device comprising a thermionic tube having a control grid, an electron emission element, an anode and an auxiliary grid-like electrode, a circuit for applying signal potentials between the control grid and electron emission element of said tube, said control grid being maintained at a negative potential with respect to said cathode, a filter circuit which responds to a band of frequencies connected between the anode and the emission element of said tube by way of a source of potential, a filter circuit connected between said auxiliary electrode and the emission element of said tube by way of a source of potential greater than said first named source of potential, an output circuit connected to the anode of said tube and means for tuning both of said filter circuits to a frequency which is a function of the input frequency.

7. The method of signalling with signals which cover a considerable frequency range which includes the steps of, modulating carrier frequency oscillations of intermediate frequency with said signals, dividing the frequency of the energy obtained from said modulation to reduce the width of the frequency band, rectifying said energy, modulating high frequency oscillations with the energy resulting from said rectifying process, receiving the energy resulting from said last modulation, demodulating said received energy, modulating intermediate frequency oscillations with energy resulting from said demodulation, multiplying the frequency of said energy resulting from said modulation to expand the width of the signal representative frequencies and rectifying the multiplied frequencies to render the original signal.

8. A device for altering the width of a band of signal frequencies impressed on carrier waves comprising, a thermionic tube having an anode, an electron emission element, a control grid electrode and an auxiliary electrode, a circuit for impressing said signal modulated waves on the control grid electrode of said tube, a filter circuit comprising a pair of inductances shunted by capacities connected in parallel, an inductance and a capacity in series in one of said connections, said filter circuit being connected on the one hand to said anode, and on the other hand to a source of potential, a similar filter circuit connected between the auxiliary electrode and a source of potential greater than said first named source of

potential and an output circuit connected with said anode.

9. The combination with a source of signal oscillations which cover a considerable frequency spectrum of a phase shifter connected with said source, a modulator connected with said phase shifter, an intermediate frequency oscillator connected with said modulator, a thermionic tube having its input electrodes coupled to said modulator, a filter circuit connecting an auxiliary electrode of said tube to the electron emission element by way of a source of potential, said filter circuit being tuned to a function of the frequencies in the output of said modulator, a second filter circuit connecting the anode of said tube to a point on said first named source, said second named filter circuit being tuned to a function of the frequency in the output of said modulator, and a utilization circuit connected with the anode of said tube.

10. The combination with a device responsive to signal modulated oscillations of a modulator, connected to said device, an intermediate frequency oscillator connected to said modulator, a thermionic tube having its control grid and cathode connected to said modulator, a filter circuit connected between the anode and cathode of said tube, said filter circuit being tuned to a frequency which is a function of the frequency band in the output of said modulator, means for energizing the electrodes of said tube so that oscillatory energy will be produced in said filter circuit when energy is applied from said modulator to the control grid and cathode of said tube, and a rectifier coupled to the output of said thermionic tube and a phase shifter for coupling the output of said rectifier to a load circuit.

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Disclaimer

2,220,689.—*Henry Shore, Elizabeth, N. J.* OSCILLATORY CIRCUITS. Patent dated Nov. 5, 1940. Disclaimer filed July 28, 1950, by the assignee, *Radio Corporation of America*.

Hereby enters this disclaimer to claims 1 to 10 inclusive of said patent.
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