Oct. 25, 1938. G. L. USSELMAN 2,134,065

MODULATOR

Original Filed March 21, 1931 2 Sheets-Sheet 1

Fig. 1

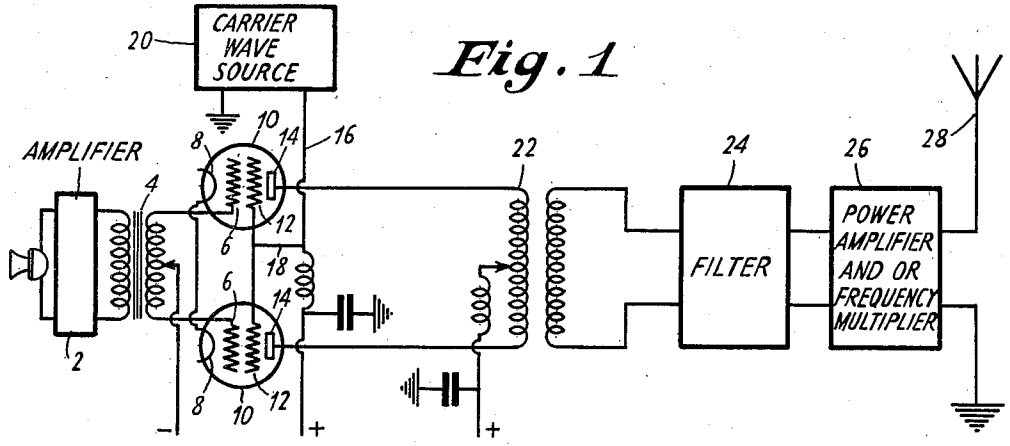


Fig. 2

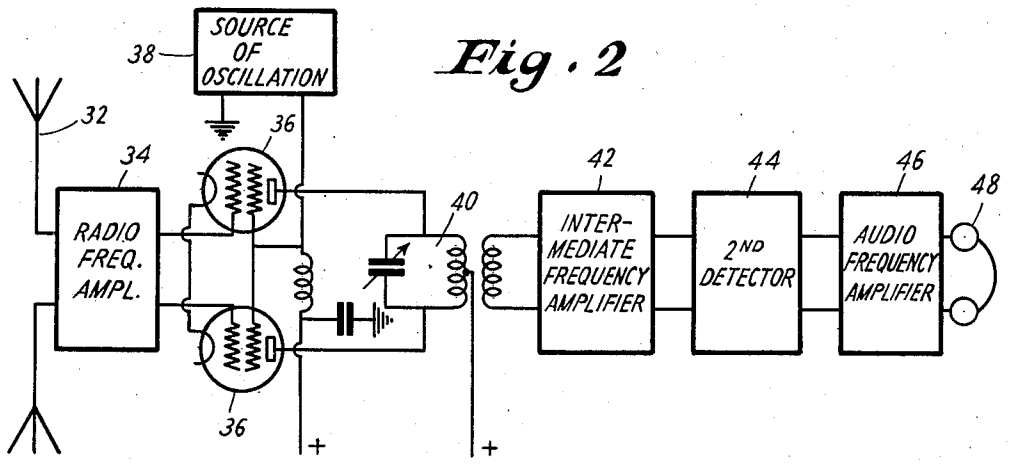
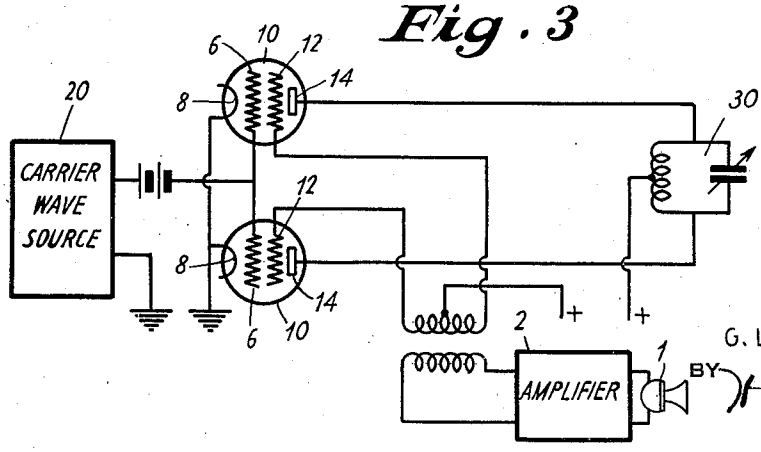


Fig. 3



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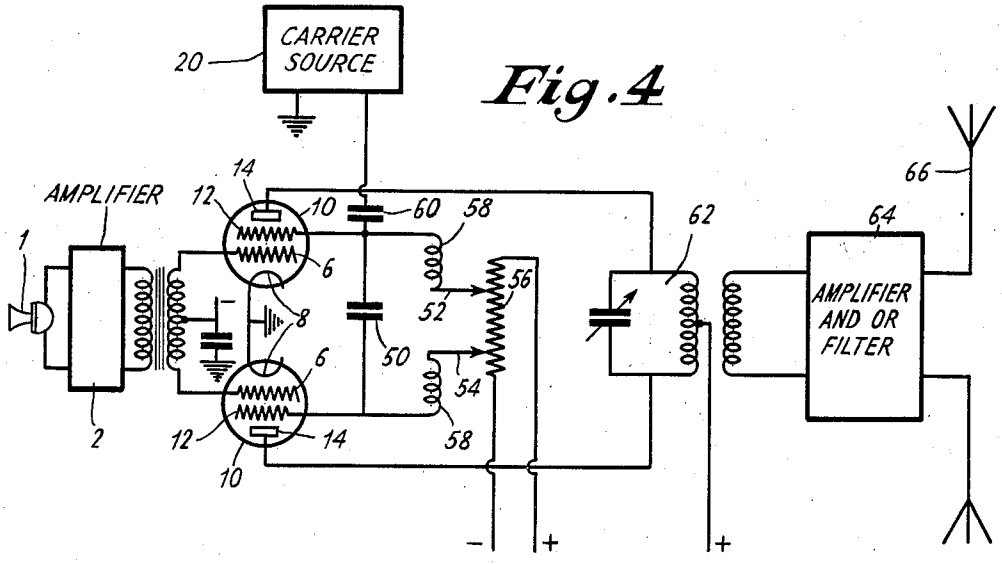


Fig. 4

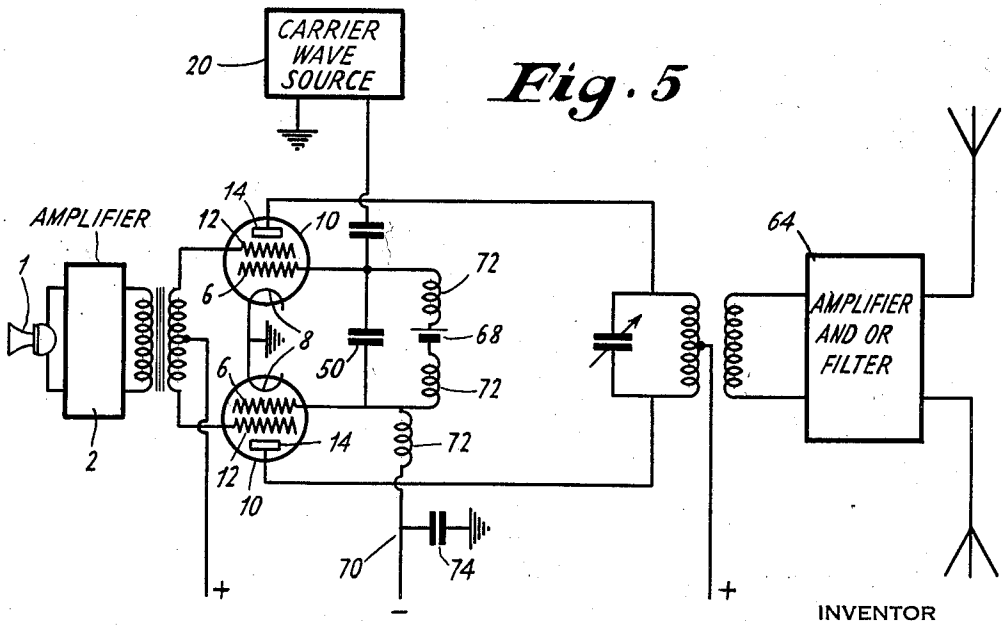


Fig. 5

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UNITED STATES PATENT OFFICE

2,134,065

MODULATOR

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Original application March 21, 1931, Serial No. 524,247. Divided and this application January 29, 1936, Serial No. 61,259

3 Claims. (Cl. 179—171)

This invention relates to modulators and especially to sideband modulators of the electron discharge device type. This application is a division of United States application Ser. No. 524,247, filed March 21, 1931, Patent #2,074,440, dated March 23, 1937.

In order to produce sideband energy from carrier energy and energy of a frequency other than the carrier energy while at the same time suppressing the carrier energy, it has been proposed to apply carrier energy to the grids of a pair of triodes cophasally and the other energy, usually modulating energy, to the same grids in phase opposition. By virtue of the fact that the two sources of energy were coupled to the same electrodes, undesired interaction between them frequently took place.

It is an object of this invention to provide a carrier suppression modulator wherein such interaction is effectively prevented. Briefly, to do so, according to my present invention, I use four element or screen grid tubes, or in other words, tubes having more than three electrodes for electron discharge devices, to like pairs of grids of which I apply either the modulating or carrier energy in phase opposition and to the other grids I apply the carrier or modulating energy cophasally. In this manner the energy sources are kept separate and prevented from interacting upon one another.

While the carrier or energy of higher order of magnitude in frequency may be applied to either of the grids of the screen grid tubes, I prefer to apply it cophasally to the screen grids of my improved carrier suppression modulator.

Sometimes it is desirable that a small amount of carrier energy be transmitted in addition to the sideband energy. Accordingly, a further object of the present invention is to provide an arrangement of electron discharge devices wherein carrier energy is only partially suppressed. More specifically, and one way of doing so, according to the present invention, grids of screen grid tubes are polarized differently and carrier alternating energy supplied thereto. Other grids of the system are supplied with modulating energy. As a consequence, in the output circuit of the tube arrangement, sideband energy and a certain amount of carrier energy will appear.

Other general objects of my present invention are to provide transmitting and receiving systems utilizing my improved sideband or carrier suppression modulator.

While I have sought to define my invention in its broadest aspects in the appended claims, it may best be understood, however, both as to its structural organization and mode of operation by referring to the accompanying drawings, wherein:

Fig. 1 is a wiring diagram of a transmitting system having a sideband modulator therein comprising a pair of screen grid tubes to which carrier energy is applied to the screen grids cophasally and modulating energy to the usual grids or grids adjacent the cathodes in phase opposition;

Fig. 2 is a schematic diagram of a receiving system using my improved carrier suppression modulator;

Fig. 3 illustrates another form of my sideband modulator wherein relatively low frequency energy is applied to the screen grids or grids adjacent the anodes of a pair of electron discharge devices and wherein relatively high frequency energy is applied to the usual grids or grids adjacent the cathodes; and

Figs. 4 and 5 illustrate carrier suppression systems, according to the present invention, wherein the carrier is not totally but only partially suppressed.

Referring to Fig. 1 of the accompanying drawings, relatively low frequency modulating energy, which may be considered energy of one order of magnitude in frequency, from a suitable amplifier 2 connected with source 1 is applied in phase opposition through the medium of transformer 4 to the usual grids 6 adjacent the cathodes 8 of electron discharge devices 10, of the screen grid type. To the screen grids 12 of the grids adjacent to the anodes 14 of tubes 10, there is applied cophasally through conductors 16, 18 from a suitable source 20, carrier potentials or energy which may be considered energy of a different order of magnitude in frequency relative to energy from source 2.

By virtue of the application to the grids of electron discharge devices 10 of energy of different frequencies, there will appear in the output circuit 22 coupled to the devices, energy of frequencies equal to the sum and difference of the frequencies from sources 2 and 20. Energy of carrier frequency will not appear in the output circuit 22 for the reason that the carrier energy is applied cophasally to the grids 12 and the carrier components appearing in the output circuit 22 effectively self cancel one another by virtue of the pushpull arrangement of tubes 10.

For successful operation, the power supply

source for biasing the grids and especially the screen grids, should be very constant for otherwise a large regulation in biasing voltages on the grids would cause modulation of the carrier at frequencies corresponding to the regulation. For the same reason the regulation of the high frequency generator which supplies the carrier voltage to the screen grids, should be constant to prevent extraneous modulation.

Inasmuch as the carrier and modulating energies are applied to different electrodes, they are, of course, effectually separated and cannot interact upon one another for the inter-electrode capacity coupling the two sources together is so small that the two sources can be considered for all practical purposes electrically separated.

Output energy from output circuit **22** may be fed, if desired, to a filter **24** and one sideband allowed to pass into an additional power amplifier or frequency multiplier or both included in **26** if found necessary. The amplified energy from amplifier **26** may then be radiated or electromagnetically propagated by the action of antenna **28**.

If desired, the sideband modulator of Fig. 1 may be replaced by the scheme shown in Fig. 3 wherein carrier energy from source **20** is fed cophasally to the usual grids or grids adjacent the cathodes of tube **10**; whereas the modulating energy is fed in phase opposition to the screen grid of electron discharge devices **10**. The output circuit **30** may be given a characteristic sufficiently broad to pass both sidebands generated or preferably, it is proportional so as to pass either the upper or lower sidebands produced as found desirable.

The output of pushpull connected screen grid tubes **10** may be taken from the output circuit **30** and fed to any suitable filter such as **24** of Fig. 1, and then may, if found desirable, be impressed on a frequency multiplier and amplifier such as **26** of Fig. 1, and then may be transmitted by means of a radiating antenna, such as **28** of Fig. 1.

It should be clearly understood, that a similar arrangement may be used wherein the voltage on the grids adjacent the cathodes is varied in accordance with signal potentials by an arrangement similar to that shown in Fig. 3. In that event, the cathode and anode connections to the source **3** would be reversed so that a suitable biasing potential is applied to the usual grids. To the screen grids of such an arrangement high frequency energy would be applied cophasally as shown in Fig. 1.

My present invention is not, of course, limited to transmitting systems but may be used with equal advantages in a receiving system of the heterodyne type such as shown, for example, in Fig. 2. Electromagnetically propagated signal modulated energy collected upon antenna **32** may be amplified as desired by a radio frequency amplifier **34** and then fed in phase opposition to the grids adjacent the cathodes of electron discharge devices **36**. Locally generated energy for producing intermediate frequency energy from a local oscillating source **38** is applied, as shown, to the screen grids of tubes **36**, cophasally. The output circuit **40** of electron discharge devices **36** may be tuned or have suitable filters associated therewith to pass either the upper or lower sidebands into the intermediate frequency amplifier **42**.

Energy from intermediate frequency amplifier **42** is then fed into a second detector or demodulator **44** amplified, if desired, by a suitable low frequency amplifier **46** and translated by a suitable device such as telephones **48**. It is to be clearly understood, of course, that in Fig. 2, for example, the incoming frequency energy may be fed to the screen grids of the tubes **36** either cophasally or in phase opposition in which cases the locally generated energy would be applied to the usual grids of the tubes in phase opposition or cophasally respectively.

Should it be desired that a portion of the carrier energy appear in the output circuit of a modulator, arrangements such as shown in Figs. 4 and 5 may be used to good advantage.

In Fig. 4, signal modulating energy is applied to the grids **6**, as shown, which are those adjacent the cathodes of devices **10**. The screen grids **12** of tubes **10** are connected in parallel for high frequency currents by condenser **50** and are biased or polarized different amounts by independent taps **52**, **54** leading to potentiometer **56** suitably supplied with potential as indicated. To prevent the flow of high frequency currents from source **20** in potentiometer **56**, chokes **58** are inserted in series with the tapping connections **52**, **54**. As indicated above, the values of **50** and **58** are such that the high frequency energy from **20** is applied substantially in phase to the screen grids **20**.

Consequently, carrier energy from source **20** will be fed cophasally to the screen grids **12** by condenser **60**, but, as the screen grids **12** or grids adjacent the anodes of tubes **10** are polarized differently, a certain amount of carrier energy will always appear in the output circuit **62** of screen grids **10**. The carrier energy and the sideband energy may then be amplified by suitable amplifier **64** and radiated by means of a suitable antenna **66**.

Of course, by including in amplifier **64**, suitable filters, the carrier energy and one or the other sidebands may be transmitted as desired rather than transmitting both sidebands and the carrier.

The arrangement shown in Fig. 5 differs from that shown in Fig. 4 in that modulating energy is applied to the screen grids **12** or the grids adjacent the anodes of tubes **10** whereas carrier energy from source **20** is applied cophasally through the action of high frequency paralleling condenser **50** and reactance **72** to the grids **6** adjacent the cathodes of tubes **10**.

In order to pass a certain amount of the carrier energy, a source of potential, here shown in the form of a battery **68**, is inserted in series with the grids **6** and between the polarizing lead **70** for both grids. Source **68**, therefore, will render the upper grid **6** different in static potential from that of the lower grid **6** of the tubes **10**. High frequency energy may be prevented from flowing in the battery **68** and lead **70** by suitable choke coils **72**. As an additional safeguard, lead **70** may be grounded for radio frequency currents by condenser **74**.

It is obvious that various minor changes will readily suggest themselves to those skilled in the art. Consequently, my invention is not to be limited to the modifications described, but solely by the scope of the claims which I have appended hereto.

What is claimed is:

1. In a transmitting system, a pair of electron discharge devices each having a cathode, an anode, a grid adjacent the cathode and a grid adjacent the anode, a common output circuit cou-

pled to the anodes of said devices, a source of modulating energy, a balanced push-pull circuit coupling said source in phase opposition to the grids of said devices adjacent said cathodes, a source of relatively high frequency energy coupled cophasally to the grids adjacent said anodes through means separate from said first named means, resistive means for applying different direct current potentials to the grids adjacent said anodes, means for amplifying the resultant energy in said output circuit, and means for transmitting the amplified energy.

2. In a system for transferring intelligence from one geographically situated point to another by propagated electro-magnetic wave energy derived from the flow of high frequency undulatory electrical currents operated upon in accordance with the intelligence to be transmitted, the combination of a pair of electron discharge devices each having a cathode, an anode, a grid adjacent the cathode and a grid adjacent the anode, resistive means for subjecting the grids adjacent the anodes of said devices to uni-directional potentials of different values, means for subjecting the same grids to undulatory carrier potentials cophasally, and balanced circuit means for subjecting the grids of said devices adjacent said cathodes to potentials of another order of frequency and in phase opposition.

3. In a signalling system the combination of a pair of electron-discharge devices, each having a cathode, an anode, a grid-like electrode adjacent the cathode, and a grid-like electrode adjacent the anode, circuits including a source of direct current potential connected with the grid-like electrodes adjacent said anodes for applying thereto direct current potentials of different value, a reactance in each of said circuits, a source of wave energy, a circuit connecting said source of wave energy in parallel with the grid-like electrode in each of said devices adjacent the anode for applying to said electrodes wave energy in phase, a source of modulating potentials, and transformer means interposed between said source of modulating potentials and the grid-like electrode in each of said devices adjacent the cathode to apply thereto modulating potentials in phase opposition.

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