June 14, 1938. G. ULLBRICHT 2,120,303

GAIN CONTROL DEVICE

Filed April 21, 1937

Fig. 1

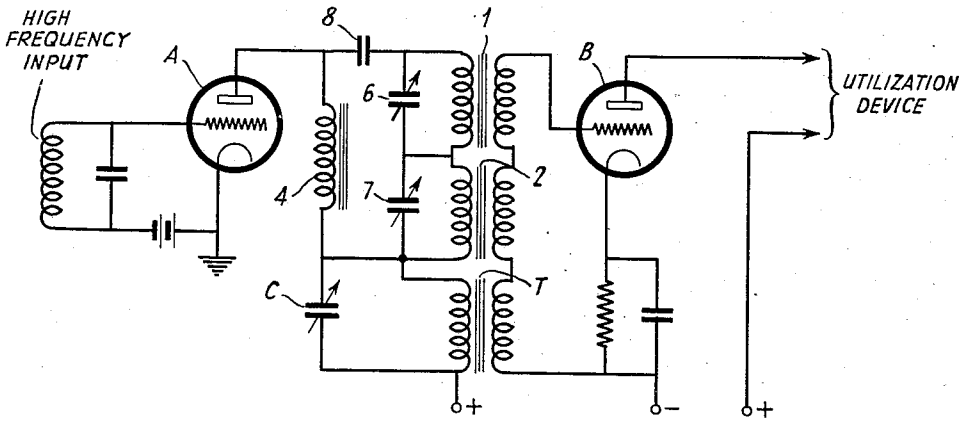


Fig. 2

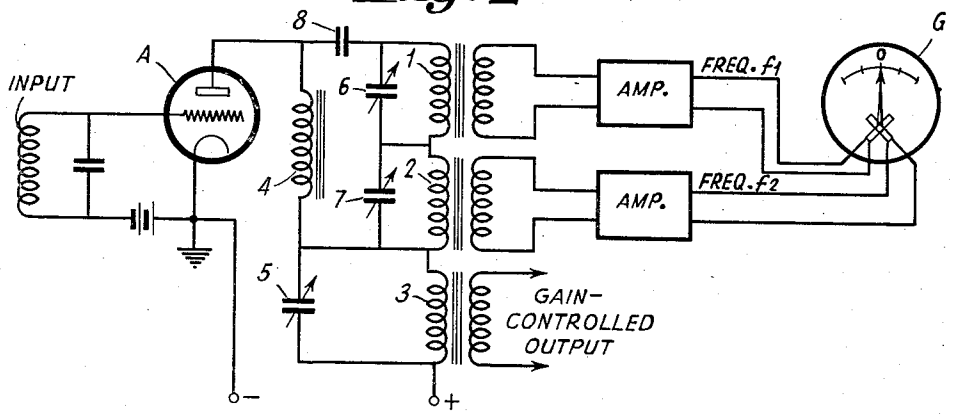
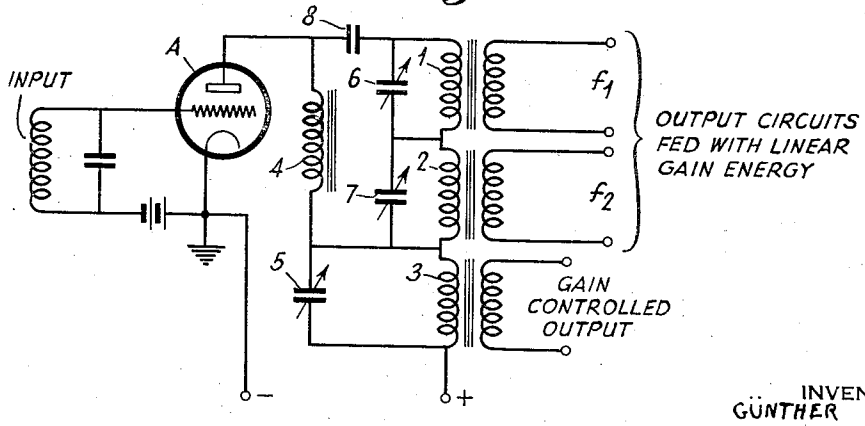


Fig. 3



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GAIN CONTROL DEVICE

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5 Claims. (Cl. 250—20)

This invention relates to gain control devices and more particularly to electrical circuits such as used in radio apparatus as well as for voltage regulators and other control devices.

It is among the objects of my invention to provide a circuit arrangement having a frequency response characteristic such that the gain ratio is controlled by variations in the low frequency component of the applied input energy. The circuit arrangement may include one or a plurality of transformers tuned to a desired audio-frequency and so dimensioned that the direct current component of the rectified high frequency or audio-frequency varies the initial magnetization in the transformer and at the same time varies the natural frequency response of the transformer itself. Other elements may be provided in the circuit in combination with the transformer so as to obtain output energy of varying amplitudes and of varying frequency selective characteristics.

The device presently to be described is capable of use as an automatic volume control device in radio transmitters or receivers. It is also useful as a voltage regulator. Again it may be used in connection with radio receivers such as carried on board an aircraft wherein it is required that the pilot shall be able to listen to communications such as instructions for guiding him in his flight and also for obtaining bearings and for following a directional beam as when making a blind landing.

Among the advantages to be derived from the use of my invention it may be mentioned that the device itself is very simple in construction and avoids a certain amount of duplication of apparatus such as was heretofore considered necessary in order to fulfill all of the required functions of the apparatus that was duplicated.

My invention will now be described in detail, reference being made to the accompanying drawing, in which

Figure 1 shows a circuit arrangement, the principles of which it is necessary to explain in order to expand the broad idea of the invention;

Fig. 2 shows a preferred embodiment of the invention; and

Fig. 3 shows a modification suitable for certain particular requirements.

Referring to Fig. 1, I show illustratively an electron discharge tube A which may serve as a rectifier of high frequency energy impressed on its input circuit between the cathode and the control grid. This input circuit is conventional. The output circuit includes the primary of a transformer T, this primary being shunted by a condenser C for tuning purposes. The secondary of the transformer T feeds to an amplifier tube B, the output circuit for which may include any desired utilization device.

There are also shown in Fig. 1, two transformers 1 and 2, the secondaries of which are in series with the secondary winding of the transformer T. The primaries of the transformers 1 and 2 constitute inductive portions of two resonant circuits, which circuits include the variable capacitors 6 and 7 respectively. The primary windings of the transformers 1 and 2 are not traversed by direct current components of the output energy from the tube A because such components are excluded by the capacitor 8. Where the secondaries of the three transformers 1, 2 and T are series connected, as shown in Figure 1, and all feed to the grid of a single amplifier tube B, the advantages of furnishing a portion of this input energy through the transformers 1 and 2 are not so much apparent as in the other modifications of my invention shown in Figs. 2 and 3. These further advantages will, therefore, be brought out in more detail in describing the other modifications. It is to be understood, however, that in order to provide standard equipment which shall have a variety of different uses, the complete array of transformers 1, 2 and T, or as designated in the other modifications 1, 2 and 3, may be provided with alternative connecting arrangements so that the different functions of the apparatus may be performed at different times with slight changes in these connections.

The plate current through the rectifier tube A determines the magnitude of the initial magnetizatin of the iron core in the transformer T. As the magnetization approaches saturation detuning occurs, hence the gain in the succeeding amplifier stage is controlled by the amplitude of the high frequency input energy applied to the detector A. The range of variation in the transformation ratio through the transformer T is equal to

$$\frac{1}{d}$$

provided the secondary side of this transformer has no load, d being the damping component of the resonance circuit. The value of d can easily be maintained within 5% so that the degree of amplification can therewith be varied up to twenty times the value of d. It follows from this that it is possible to obtain a very steep and narrow resonance curve in the characteristic of

the transformer T and its associated condenser C.

The design of the circuit shown in Fig. 1 is adapted to pass a considerable direct current component through the transformer T and the detector tube A. This detector tube A is not necessarily of the triode type but other forms of rectifier may be used if desired.

It is within the scope of the invention to provide a plurality of audio-frequency control devices in cascade, each similar to the one shown in Fig. 1. In this case the high frequency detector stage is followed by one or more audio-frequency detector and amplifier stages. The audio-frequency amplifier stages following the demodulator and a stage of second detection may be of any well known construction and it will be understood by those skilled in the art that in this case the discharge tube B may serve as a second detector and it may have interposed between its input and the secondary of the transformer T one or more stages of intermediate frequency amplification if desired.

When using a one-way rectifier for the audio-frequency detectors the audio-frequency of the fundamental wave is passed through this detector and the high frequency waves are suppressed. When two-way rectification is provided the low frequency output may be doubled.

Obviously my invention may be used in an audio-frequency amplifier without reference to the question of whether the low frequency is or is not a modulation superimposed upon a carrier wave.

My invention has particular utility in systems wherein radiated signals of a predetermined high frequency are received, but where these signals are differently modulated for different purposes. For example, in receiving apparatus for guiding an aircraft to a blind landing a guiding beam may be used, the field strength of which serves after rectification for actuating an indicating instrument thereby to show the distance between the aircraft and the transmitter. In this case it is essential that the gain in the amplifier of the receiver shall be held at a constant ratio so that the indications may be made in accordance with the received field intensity of the signals. On the other hand, where the receiving apparatus is to be used at times for other purposes, as in communications between the transmitter and the air pilot, an automatic volume control device is very desirable. For such purposes, even though the high frequency carrier wave may be differently modulated as compared with the modulations for the directional beam, it is possible to apply the volume control methods herein shown without destroying the effectiveness of the directional beam system.

Hitherto it would have been necessary to provide two separate receivers for the different functions which are to be fulfilled as described above, one of the receivers being provided with an automatic volume control device and the other being without such a device. My invention makes it possible, however, to combine these essential functions in one receiver. This is particularly true where the received signals are modulated with different low frequencies for the different functions.

Fig. 2 illustrates one preferred method of carrying out the invention for obtaining control of the gain with respect to certain low frequencies without controlling the gain for other low frequencies. The circuit shows a detector A the same as in Fig. 1, but the output circuit from this tube includes a choke coil 4 leading to a tuned circuit which comprises the primary of the transformer 3 and a variable condenser 5. The anode potential is applied to the tube A through the primary winding of the transformer 3 and through the choke coil 4.

In shunt with the choke coil 4 is a circuit arrangement comprising primary windings of two transformers 1 and 2, each shunted by a suitable condenser 6 and 7 respectively and this entire shunt circuit is coupled to the anode of the tube A through a condenser 8 which prevents the flow of direct current through the windings of the transformers 1 and 2.

With respect to the frequencies which traverse the tuned circuits 1—6 and 2—7, it will be seen that these are not gain-controlled in the transformers 1 and 2. Therefore, the energy developed in the secondaries of the transformers 1 and 2 possesses amplitude variations which bear a linear ratio to the input energy applied to the detector A.

By using signals of two different modulation frequencies and by tuning the circuits 1—6 and 2—7 respectively to these modulation frequencies, a directional indicator of any well known type may be made operable in the ouput circuits connected to the transformers 1 and 2. Thus, two slightly overlapping directional beams may be modulated respectively by low frequencies f_1 and f_2 to which the circuits 1—6 and 2—7 are made resonant respectively. Then, for example, an indicating instrument G may be provided with opposing coils and so connected to the secondaries of the transformers 1 and 2 (through amplifiers, if desired) as to cause a deflection of the needle to either side of the mid-position (0-point) depending upon the ratio between the amplitudes of the received modulations of the two directional signals. Thus any deviation of the aircraft from a course midway between the axes of the two directional beams may be indicated.

The energy developed in the secondary of the transformer 3 is, however, gain controlled in the same manner as described above in connection with Fig. 1. The primary of the transformer 3 in parallel with the condenser 5 may, therefore, be tuned to a given modulation frequency different from the modulation frequencies which are to be received without gain control. If the average current through the coil 3 is increased, the iron core becomes saturated and the inductance decreases so that the amplification of low frequencies is reduced, although the amplification of high frequencies is not reduced to an appreciable extent.

Where it is desired that different functions shall be performed in accordance with the low modulation frequencies of the received energy, it is, of course, within the scope of my invention to provide separate and distinct circuits, each including the secondary windings of the respective transformers 1, 2 and 3. In this case it will be seen that the output energy from transformers 1 and 2 will not be gain-controlled, whereas the output energy from the secondary of the transformer 3 will be subject to gain control.

A modification of the invention suitable for the purposes mentioned in the preceding paragraph is shown in Fig. 3. This figure is self-explanatory in view of the description of the other figures as given above.

In the foregoing description I have dwelt more

particularly upon the principles involved in the carrying out of my invention in order to show how automatic gain control may be provided as a result of varying the amplitude of the direct current component traversing the winding of a transformer in circuit with the output circuit of a rectifier. Such a transformer has been shown in connection with one or more transformers not traversed by the direct current component and, therefore, adapted to function without distortion. It will be appreciated by those skilled in the art that numerous applications of the invention are possible and that the circuit arrangements herein shown and described are merely illustrative.

I claim:

1. An electrical circuit having an alternating current rectifier, a resonant circuit connected to the output side of said rectifier and having a natural frequency which renders it variably responsive to modulation-frequency currents from said rectifier, means including a transformer having a primary winding in said resonant circuit and having a saturable magnetic core for varying the frequency response characteristic of said resonant circuit in dependence upon the amplitude of the direct current component of the energy traversing said primary winding, a second transformer whose primary is in circuit with the primary of the first said transformer, and means including a blocking condenser for excluding direct current components from the primary of the second said transformer only.

2. A circuit arrangement having an alternating current rectifier, an iron core transformer in the output circuit of said rectifier, said transformer being tuned to a low frequency and so dimensioned that its frequency response characteristic is rendered variable in accordance with the degree of saturation of its core, a second transformer having a primary winding in circuit between one of the terminals of the primary winding of the first said transformer and the output circuit of said rectifier, and means for blocking the flow of direct current through the primary of the second said transformer.

3. An arrangement according to claim 2 and having a choke coil directly in series between the output circuit of said rectifier and the interconnection from one to the other of the two transformer primaries.

4. A circuit arrangement comprising a demodulating discharge tube having a high frequency input circuit and a low frequency output circuit, a plurality of series connected primary windings for respectively different and differently tuned iron core transformers, said primary windings being fed with low frequency currents from the output circuit of said discharge tube, means for excluding direct current components from at least one of said transformer primaries, thereby to render the transformation ratio linear therein, and means for admitting direct current components to another of said transformer primaries thereby to vary its impedance in dependence upon the degree of saturation of its transformer core.

5. A circuit arrangement according to claim 4 and having a direction finding indicator responsive to output energy from at least one of said transformers from which direct current is excluded, and a radio receiver responsive to output energy from the transformer having a variable impedance.

GÜNTHER ULLBRICHT.