July 12, 1932. B. G. BJORNSON 1,866,592

VOICE OPERATED REPEATER CIRCUIT

Filed June 7, 1930 2 Sheets-Sheet 1

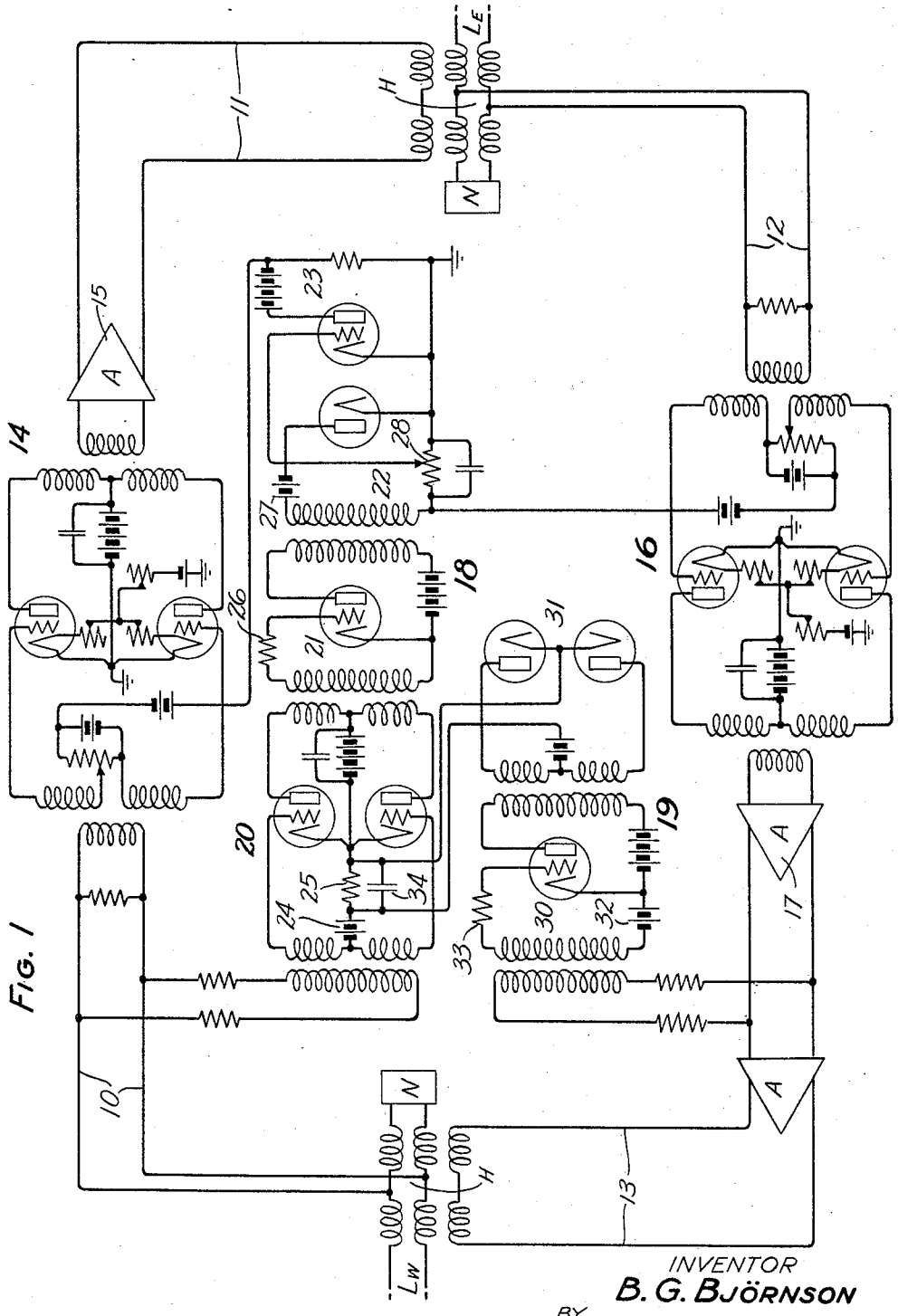

FIG. 1

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FIG. 2

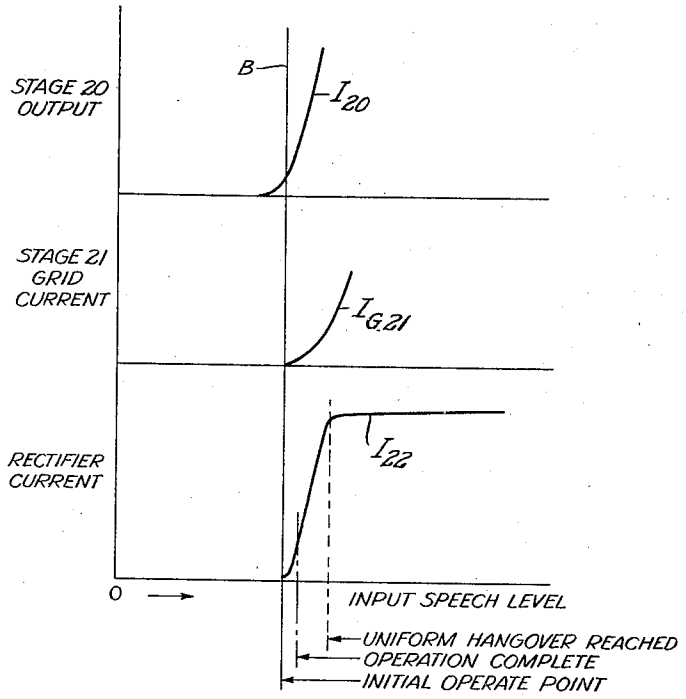
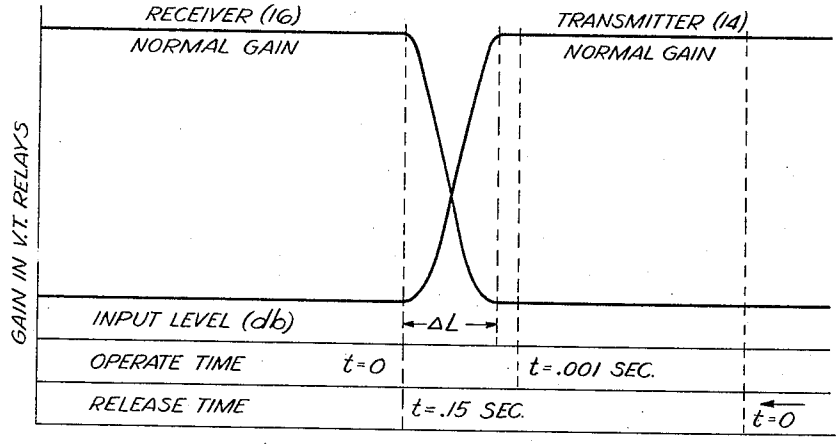


FIG. 3



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UNITED STATES PATENT OFFICE

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VOICE OPERATED REPEATER CIRCUIT

Application filed June 7, 1930. Serial No. 459,652.

The present invention relates to voice operated transmission circuits, particularly to two-way transmission circuits containing oppositely directed repeaters which are conditioned for operation one at a time.

An object of the invention is to improve the operation of voice operated systems, particularly as regards speed of operation, sensitivity and freedom from false operation.

Voice operated circuits are known in the art employing an eastward and a westward repeater which are rendered operative one at a time by speech waves arriving at the repeater point for transmission through the repeater. To condition the respective repeaters for operation, some of the voice energy is rectified to produce a voltage which is used to change the normal bias on one or both of the respective repeaters so that one repeater remains blocked while the other is rendered in condition to repeat.

In order to prevent clipping, that is, loss of any of the speech either at the beginning or at the end of a word, it is necessary that the repeater be placed in operating condition sufficiently soon to transmit the initial portion of the speech and also that the repeater have a sufficient hangover time to accommodate the end portion of a word or syllable. Where delay circuits are not used to delay application of the speech to the repeater so as to permit longer time in which to condition the repeater, it is obvious that the voice control circuits must operate practically instantaneously if clipping is to be avoided.

The present invention is concerned principally with the use of elements in the voice control circuits which will properly time the switching and release operations and secure positive operation of the repeaters with a minimum of clipping.

While reference is made throughout to voice operated circuits and to two-way transmission, it will be understood that the invention in its broader aspects is applicable to other types of transmission than speech transmission and is also applicable to one-way as well as two-way transmission.

The invention will be better understood from the following detailed description with reference to the accompanying drawings showing in Fig. 1 in schematic diagram a two-way repeater circuit in accordance with the invention and in Figs. 2 and 3, curves illustrative of the operation of the circuit of Fig. 1.

The general layout of the circuit of Fig. 1 is in accordance with prior art practice and will not require detailed description. The portion of the system which the invention is concerned in improving comprises the voice operated circuits shown in the central portion of the figure.

The west and east lines L_W and L_E respectively are each provided with hybrid coil H and balancing network N as common in the art. The west to east repeater circuit is connected between the bridged conductors 10 of line L_W and the circuit 11 connected to the series winding of the hybrid coil of line L_E. For convenience of description, this west to east repeater path will be referred to as the transmitting branch.

The east to west transmission path is connected between circuit 12 bridged across the hybrid coil of line L_E and circuit 13 leading to line L_W. For convenience of description this east to west path will be referred to as the receiving branch.

The transmitting branch contains the vacuum tube relay circuit 14 together with such amplifier stages as may be desired, indicated generally at 15. Similarly, the receiving branch comprises the vacuum tube relay 16 and amplifier 17. The amplifier rectifier is generally indicated at 18 and the receiving disabler or protector circuit is indicated generally at 19.

As in the prior art, speech waves arriving at 10 in the transmitting branch pass in part into the amplifier detector circuit 18 where they are translated into steady direct current voltage which is used to make the normally inoperative vacuum tube relay 14 operative and to disable the normally operative receiving relay circuit 16. This is done by reducing the normal negative bias on relay 14 and supplying negative bias to the grids or relay 16. Thus the amplified speech waves in the output of amplifier 15, in case of un-

balance of the network and hybrid coil of line L_E, will not find their way from circuit 12 through relay circuit 16 to amplifier 17 and set up singing around the repeater loop, because relay 16 is effectively blocked.

Similarly, received waves in the circuit 12 are transmitted through the normally operative relay circuit 16 and amplifier 17 and are impressed on the west line L_W. A portion of the waves in the output of amplifier 17 is rectified at 19 and applied to the amplifier detector circuit 18 to disable this circuit so that it is not operated by energy that may be present in circuit 10 due either to noise or lack of balance of the hybrid coil of line L_W.

The improvements provided by the present invention will now be described. As stated above, these are concerned with the design of the amplifier detector circuit 18 and the disabler circuit 19.

The amplifier detector circuit 18 comprises an initial push-pull stage 20 followed by an amplifier stage 21 and a rectifier stage 22. There is also a bias reversing stage 23 cooperating with the rectifier 22 as above described to reduce the normal bias of relay 14.

Initial push-pull stage 20 has a normal negative bias impressed from source 24 slightly in excess of a value sufficient to reduce the space current substantially to zero. It was seen in the foregoing description of the operation of the circuit as a whole that received speech waves operate through the disabler 19 to impress an additional negative bias on push-pull stage 20. This bias is applied across resistance 25. If the push-pull stage 20 had normal space current flowing through the tubes, the application of the bias to resistance 25 from the disabler would first have to reduce the space current to zero, after which a further increase in the negative bias would effect the blocking of the push-pull circuit 20 against false operation. Such sudden reduction of the space current to zero would be likely to cause the transmission of an impulse through the rest of the amplifier detector circuit 18 such as might interfere with the operation of the vacuum tube relays 14 and 16. The use of push-pull tubes in stage 20 would tend to minimize that effect especially if perfect balance could be obtained. However, by making the negative bias from source 24 such as to reduce the space current in stage 20 to zero, it will be clear that the application of additional bias to resistance 25 as described makes no change whatever in the output of stage 20 and therefore precludes the possibility of a disturbing impulse from this cause in circuit 18.

Amplifier stage 21 (which may be one of several amplifier stages, depending upon the amount of gain required in any case) contains a high resistance 26 in the grid circuit, the effect of which is to cause stage 21 to saturate quickly upon the application of waves in excess of a prescribed minimum level.

Rectifier 22 in addition to having a large resistance 28 in its circuit, also contains a negative bias voltage source 27. The effect of this is to make the rectifier marginal. That is, it does not respond to input levels below a certain minimum but transmits current only when the minimum level is exceeded.

The effect of the foregoing provisions in the amplifier detector circuit is readily seen by reference to the graphs of Fig. 2. The zero line at the left indicates the condition with no input from circuit 10. As the input level increases from zero there is a marginal range of no operation represented by the distance between the zero line and the vertical line B. This marginal region is determined by the amount of normal negative bias in stage 20. With further increase of input level stage 20 begins to transmit current in accordance with the characteristic I_{20}. On account of resistance 26 in stage 21 this stage reaches saturation very quickly after the initial input voltage is applied. This is indicated by the grid current curve I_{G21}. The rectifier current is shown by the curve I_{22}, which shows a slight marginal operation with respect to I_{20}. This is secured by the use of negative bias voltage 27. By the use of sufficient amplification between stage 20 and rectifier 22 the current curve I_{22} of the rectifier is made very steep and tube 22 is caused to reach saturation when the input level has exceeded by a few decibels the minimum operate level. As indicated by the labeled points on curve I_{22} the complete operation point is reached at an input level of less than 1 db. and preferably 0.5 db. above the initial operate point. By initial operate point is meant the point at which the circuit 18 is biased, that is, the level of input at which the amplifier detector begins to transmit current.

If there were no marginal operation in the stage 20 or in the rectifier stage 22, it will be seen that some current flow would begin to take place at a very low level of input and that doubling the level (let us say) would perhaps double the rectifier current, and so forth. However, by the use of a suitable marginal operation together with sufficient amplification, the rectifier current might be multiplied by, say, 10 for only a small percentage increase in input level. The bias in stages 20 and 22 plus the use of sufficient amplification make for a very steeply rising rectifier current curve I_{22}.

It is important from the standpoint of uniform hangover and uniform release operation, that the rectifier current curve I_{22} reach a maximum shortly after the full-operate level. This action is secured by use of the grid resistance 26 making stage 21 saturate quickly.

Without this saturation property, resulting in a current curve of the shape of I_{22}, it is apparent that speech which might have a gradually reducing level as the end of a word or sentence is approached, would gradually reduce the amplifier detector voltage with likelihood that the final portion of the speech would be lost by clipping. In accordance with the invention, however, the rectifier current is kept up at its full saturation level for input levels only slightly greater than the initial operate level. Gradually weakening input speech therefore tends to maintain the same bias voltage on the system as do stronger sounds. This action makes the release operation practically uniform for sounds of weak as well as strong ending.

In Fig. 3 curves are given showing the variations in gain with time and also with input level of the vacuum tube relay circuits 14 and 16. These curves are self-explanatory. It will be observed that the system possesses the following desirable operating characteristics:

1. The receiver is blocked before the transmitter gets into full operation.

2. The receiver gain plus the transmitter gain is less than normal gain at all times during the switching or transition period.

3. The change from normal receiving to transmitting is completed for a small change in input lever ($\Delta L = 0.5$ db.).

4. The operate time is very fast, of the order of 0.001 second, for suddenly applied tones, greater than about 2 db. above initial operate point.

5. The release time is sufficient to give a slight hangover to prevent terminal clipping.

The disabler circuit 19 of Fig. 1 comprises an initial amplifier stage 30 and a push-pull rectifier stage 31. The negative bias source 32 and the grid resistance 33 give the circuit 19 suitable marginal and saturation characteristics of the general nature indicated above in connection with the amplifier detector circuit 18. The use of a double wave rectifier 31 avoids delayed or wrongly timed operation due to phase shift. The use of a very small condenser 34 across the resistance 25 of stage 20 gives a fast build-up time for the disabling voltage. All of these factors cooperate to give fast operation and uniform operate and release conditions. By adjusting the characteristic of the full wave disabler rectifier 31 in relation to the characteristic of the push-pull tubes of stage 20 practically a straight line relation can be obtained between the disabler input level and the limit of suppression of the transmitting vacuum tube relay circuit 14. This is desirable since the limiting action of relay circuit 14 must increase to give greater protection against false operation as the waves in circuit 10 increase. The fast action secured by this circuit is necessary to prevent a momentary impulse being sent through the transmitting control circuit where no receiving delay is used, as in the case of the circuit of Fig. 1.

What is claimed is:

1. In a voice operated circuit, a circuit for producing a direct current voltage from speech energy, comprising a rectifier preceded by an amplifier, and means to make the operation of said rectifier and amplifier marginal, said amplifier reaching substantial saturation at the input level corresponding to initial operation of said rectifier.

2. In a voice operated circuit, a vacuum tube rectifier normally biased against operation, a three-element space discharge amplifier feeding into said rectifier, means to impress speech waves on said amplifier, said amplifier having a high input resistance causing the amplifier to reach substantial saturation at the input level at which the rectifier begins to operate.

3. In a voice operated circuit, a push-pull space discharge circuit normally biased against transmission, means to impress speech waves on the input of said push-pull circuit, a three-element space discharge device coupled to the output of said push-pull circuit and having a large resistance in its grid circuit, a rectifier connected to the output of said three-element device, normally biased against operation, the bias on said push-pull stage and that on the rectifier and the grid resistance of said three-element device all being proportioned to prevent production of rectifier current in response to input waves below a certain minimum level and to produce saturation current in the rectifier in response to input waves exceeding said minimum level by a small fraction.

4. In a two-way voice operated system, an amplifier rectifier circuit for controlling transmission in both directions in response to impressed speech, said circuit comprising a push-pull space discharge tube stage normally biased to the zero space current level, and means operating in response to waves from the opposite direction for increasing said bias, said push-pull stage working into amplifier rectifier stages with steeply rising characteristics reaching saturation at input levels slightly in excess of initial operate level.

In witness whereof, I hereunto subscribe my name this 29th day of May, 1930.

BJORN G. BJORNSON.