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R. S. OHL

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WAVE DETECTING SYSTEM

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FIG. 1

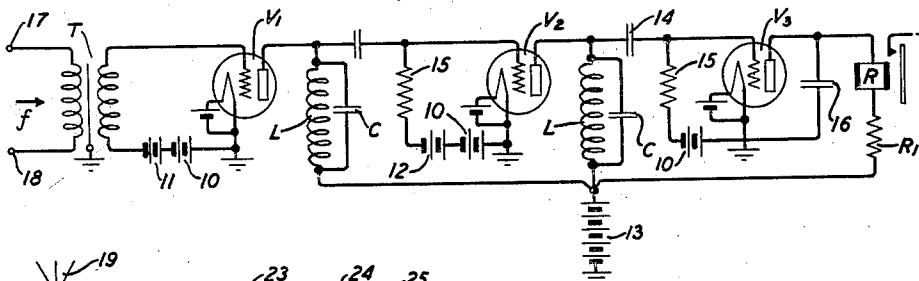


FIG. 2

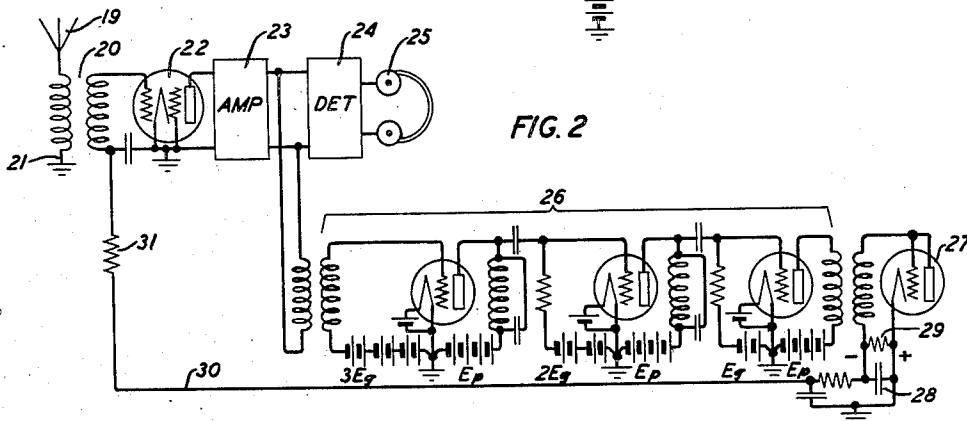
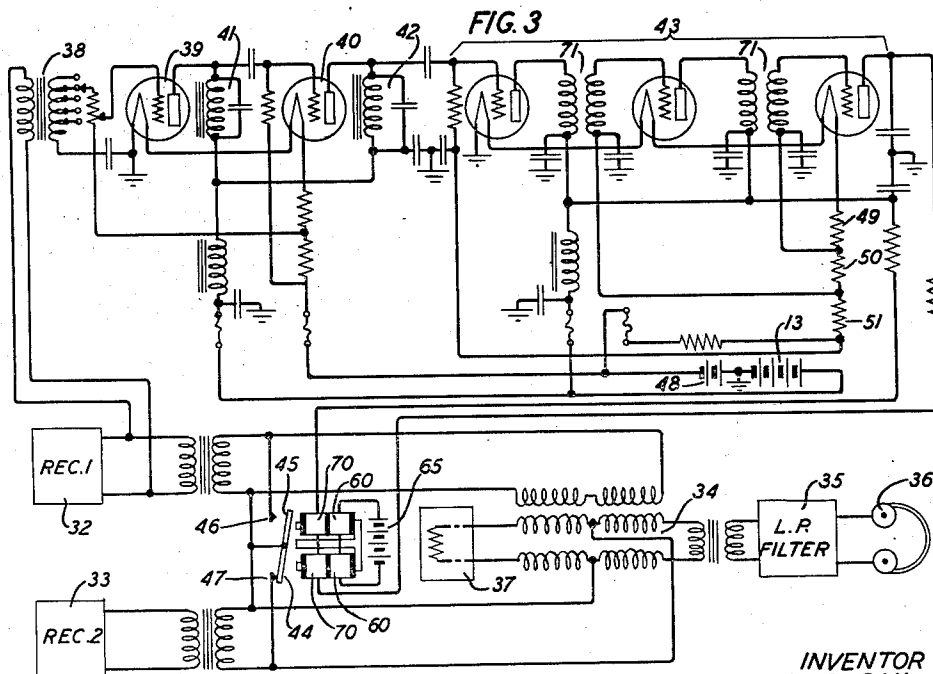


FIG. 3



INVENTOR
R. S. OHL

BY

G. H. Stevenson

ATTORNEY

UNITED STATES PATENT OFFICE

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WAVE DETECTING SYSTEM

Russell S. Ohl, Little Silver, N. J., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

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No. 563,265. Patent No. 1,950,123, March 6,
1934. Divided and this application October 10,
1933, Serial No. 692,919

10 Claims. (Cl. 250—27)

This invention relates to wave detectors and particularly to systems having increased sensitivity toward changes in the intensity of a received wave while at the same time maintaining a very rapid response to such changes.

This application is a division of my copending application Serial No. 563,265, filed September 17, 1931, which has become Patent No. 1,950,123.

In a highly sensitive detecting system it is necessary for the detecting element to respond to a very slight change in the intensity of the received wave and to produce a resultant change in the detected current which is proportionately much greater than the change in the received wave. The damping introduced into any tuned circuit or filter involved in the action of the detector should be of such magnitude as to permit the required rapidity of response.

In accordance with the invention one or more space discharge devices or vacuum tubes are employed in cascade arrangement, coupled by resonant circuits tuned to a suitably high frequency. Each of the space discharge devices is normally polarized by a potential at least sufficient to block its own space discharge. The blocking renders the system insensitive to waves of weak intensity but this condition may be overcome by initial amplification whereby waves of a preassigned strength are amplified to the point at which the blocking is overcome. Each of the space discharge devices when suitably excited is capable of providing sufficient output to overcome the biasing potential of the next tube in the series. The last space discharge device in the series is adapted to produce sufficient power to actuate a relay or other means which may form a part of a control or switching system.

The invention will be described in detail in the following specification with reference to the accompanying drawing in which Fig. 1 shows a circuit for operating a relay in accordance with the invention;

Fig. 2 shows an automatic transmission regulating system; and

Fig. 3 shows an automatic switching system employing the invention.

Referring to Fig. 1, a series of vacuum tubes V_1 , V_2 and V_3 are coupled in cascade arrangement by coupling circuits each including an inductance coil L and a condenser C . The inductance L and condenser C form a tuned circuit and the values of inductance and capacity are chosen so that the resonant frequency of the circuit is relatively high. The resonance frequency of each

coupling circuit should be high relatively to the frequency of the impressed signals. Each of the coupling circuits may be tuned to the same frequency or the frequencies may be different in which case the second tuned circuit should preferably have the higher resonance frequency. Each of the tubes is provided with a grid biasing potential by means of a battery 10, sufficient to entirely block the space discharge through the tube in the absence of any alternating current input. Tube V_1 is provided with additional negative biasing battery 11 connected in the same polarity as battery 10. The tube V_2 also has an additional polarizing battery 12 of the same polarity as the battery 10. A source of space current 13 is connected to the anodes of the tubes V_1 , V_2 and V_3 respectively through the coils L , L and a resistance R_1 . The anode of tube V_1 is coupled to the grid of the tube V_2 by a coupling condenser 14 and a grid leak is provided through a resistance 15. The plate circuit of the tube V_2 is coupled to the grid circuit of the tube V_3 by a similar condenser 14 and grid leak 15. A condenser 16 forms a by-path for alternating currents in the output circuit of the tube V_3 . A relay R is connected in series with the anode of the tube V_3 and the resistance R_1 . The transformer T , having the terminals 17 and 18, is an input device for the cascade arrangement of tubes V_1 , V_2 , V_3 .

In the operation of the system shown in Fig. 1 an alternating current is impressed upon the terminals 17 and 18 from any suitable source. The system will give no response to the impressed alternating current unless the induced electromotive force in the secondary winding of the transformer T is greater than the combined voltage of the biasing batteries 10 and 11. When the impressed current is sufficient to overcome the biasing potential, the positive tips of the wave of induced electromotive force are effective to cause space discharges in the tube V_1 . These discharges will be in the form of impulses or trains of impulses. The effect in the output circuit of the tube V_1 is to excite high frequency oscillations in the circuit LC by impulse excitation. Between the successive impulses, the tube V_1 is blocked and therefore cannot then extract energy from the operating circuit LC . The tuned circuit itself is, as usual, only slightly damped and the oscillations tend to be sustained during the period between impulses. Extended peak voltages generated in the tuned circuit LC will cause the grid of the tube V_2 to become positive at times, particularly during or immediately following each

exciting impulse. The grid filament impedance of the tube V_2 is greatly reduced while the grid of that tube is positive thereby intermittently introducing a large damping effect. This intermittent damping reduces the excessive peaks of the oscillations, further tending to sustain the oscillations at a relatively constant amplitude as long as the impulses continue to be applied. When the end of a train of impulses is reached, the oscillations of the circuit LC are quickly damped out in the usual manner.

The tube V_2 is blocked by the polarizing batteries 10 and 12 and will not respond to an impressed wave unless the voltage generated by the wave impressed across the resistance 15 is greater than the combined voltage of the batteries 10 and 12. The response of the tube V_2 to a wave which is of sufficient intensity to overcome the biasing potentials will be in the form of a train of impulses having the frequency for which the circuit LC is resonant. The second tuned circuit LC, in the output of the tube V_2 , will be excited by the train of impulses and, due to an intermittent damping introduced by the input circuit of the tube V_3 , a train of oscillations of more or less sustained amplitude will be generated.

When the alternating voltage applied to the input circuit of the tube V_2 is sufficiently great to drive the grid potential positive and cause a flow of grid current in the tube, any further increase in the applied voltage is accompanied by an increase in the grid current and an increased fall of potential in the grid leak 15. This fall of potential is in the requisite direction to establish a negative biasing potential upon the grid. This tends to prevent any further increase in the alternating voltage applied to the grid and to limit the output of the tube V_2 . The volume limiting effect is a further factor in maintaining a substantially constant amplitude of oscillation throughout the duration of the application of impulses to the tube V_1 .

The final stage employing the tube V_3 is an output or power stage and is biased only sufficiently to prevent a discharge when no alternating current is applied to the input circuit of the tube. The direct current component of the output current of the tube V_3 is delivered to the relay R. The sustained form of the train of oscillations applied to the tube V_3 is adapted to give a maximum rectified current in the tube V_3 . The advantage of the sustained wave will readily be evident when it is considered that each cycle of the wave contributes to the rectified current and that the cycles occur in rapid succession when the circuits LC are tuned to a high frequency. The original impulses which cause the discharge in the tubes V_1 are of relatively small amplitude and low frequency and are unsuited to the production of large rectified currents.

The application of a sufficiently large current at terminals 17 and 18 causes the relay R to operate. Further increase in the input current beyond the value required to operate the relay has the effect of producing an increased fall of potential in the resistance R_1 in series with the relay R. This fall of potential is in the direction necessary to oppose the potential of the battery 13 thereby preventing further appreciable increase in the current through the relay R. This limitation of the direct current through the relay results in its improved operation.

A small decrease in the current through the terminals 17 and 18 below the value necessary

to operate the relay results in a large decrease in the current through the relay R which is sufficient to cause the relay to release. Continuous slight fluctuations in the input current are effective to cause the repeated operation and release of the relay R.

Regenerative effect, if present in the system will not be detrimental provided it is not sufficient to cause self-sustained oscillations, and may be used in certain cases with beneficial results.

Fig. 2 illustrates an application of the invention to an automatic transmission regulating system in which the device of the invention is utilized to rapidly generate substantial currents for control purposes. The system is shown in connection with a radio receiver having an antenna 19 connected through a coupling transformer 20 to ground 21. The transformer 20 is arranged to feed energy into a controlled amplifier 22 connected in cascade with further stages of amplification 23, a detector 24 and a telephone receiver 25. For control purposes a connection is provided for supplying a portion of the energy from the output of amplifier 23 to a circuit 26 similar to the system shown in Fig. 1. Instead of being adapted to operate a relay as shown in Fig. 1, the last stage of the circuit 26 is arranged to control a vacuum tube rectifier 27. A filter or time constant circuit 28 is associated with the rectifier 27.

The rectified current from the rectifier 27 is directed through the resistance 29 to ground. The negative terminal of resistance 29 is connected through a conductive portion of the filter 28, a lead 30 and a resistance 31 and the secondary of the transformer 20 to the control grid of the amplifier 22. The cathode of the amplifier 22 is grounded, with the result that the potential across the resistance 29 is applied between the control grid and cathode of the amplifier 22 as a biasing potential.

The system 26 is further modified over the arrangement shown in Fig. 1 by the use of separate plate batteries for the respective vacuum tubes instead of the common battery 13. Also the biasing potentials applied to the successive grids in circuit 26 are multiple values of a potential E_g and are arranged in the descending order $3E_g$, $2E_g$, and E_g from the first stage to the last. Identical vacuum tubes are used in all the stages. This arrangement of the grid potentials in a descending arithmetical series has been found very satisfactory in practical use where exceedingly stable operation is desired together with a moderate but not exceedingly high rate of change in the output current for small changes in the input.

In the operation of the system of Fig. 2 a small change in the alternating current output of amplifier 23 actuates the system 26 to produce a large change in the rectified current delivered by rectifier 27 through resistance 29. A correspondingly large change is produced in the potential across the resistance 29 and consequently a large change is effected in the biasing potential on the grid of the amplifier 22. The change in the biasing potential is found to be proportional to the change in the output of amplifier 23 over an extended operating range. The connections are such that the bias becomes more negative when the output increases and less negative when the output decreases and thus there is effected a powerful control upon the gain of the amplifier 22 in the proper direction to restore the output of amplifier 23 to its former value. If the output current undergoes a change in amplitude so

abrupt as to be undesirable, the change in the potential across the resistance 29 is delayed and smoothed out by the action of the filter 28 so that the correction of the gain in the amplifier 22 is not objectionable. This limitation is useful in insuring that the control system will not respond to unusually sudden changes of brief duration nor to currents of the signaling frequencies.

Due to the negative bias on the first tube, the system 26 will not be actuated unless the output of amplifier 23 is greater than a certain minimum level sufficient to overcome the bias. Consequently the gain control feature of the system of Fig. 2 is inactive at low energy levels and comes into play at higher levels.

Fig. 3 shows another application of the invention in the form of a system for automatically switching from one radio receiver to another to avoid the undesirable effects of fading. In this system the device of the invention is employed to operate a switching relay. A main receiver 32 and a relief receiver 33 are arranged to be connected alternately through a balanced three-winding transformer 34 and a low pass filter 35 with a telephone receiver 36. Receivers 32 and 33 are preferably located at points spaced several wave lengths apart so that fading does not occur simultaneously in them. The filter 35 and receiver 36 are balanced by means of the balancing network 37. The main receiver 32 is adapted to generate, in addition to the desired signal currents, a control current of a frequency preferably above the range of the desired signals.

For the purpose of switching in the relief receiver when required, a connection is provided for impressing a portion of the energy output of receiver 32 upon a transformer 38 and amplifying tubes 39 and 40 connected in cascade. The amplifiers 39 and 40 are tuned for the control frequency by means of resonant circuits 41 and 42. The resonant circuit is coupled to a detecting circuit 43 very similar to the system of Fig. 1, but connected to a polarized relay 44 instead of the neutral relay R. The relay 44 has an armature 45 pivoted at the center; contacts 46 and 47, adjacent the respective ends of the armature; a pair of polarizing windings 60, 60 and a pair of operating windings 70, 70. The windings 60, 60 are energized by current supplied from a polarizing battery 65. The armature 45 has a common connection to the respective output circuits of receivers 32 and 33. Contact 46 is connected to the output of receiver 32 and forms, when closed by armature 45, a short circuit across the output of receiver 32. Contact 47 is connected to the output of receiver 33 and forms, when closed by armature 45, a short circuit across the output of receiver 33.

The detecting circuit 43 comprises three vacuum tubes coupled by resonant transformers 71, 71. The tubes are supplied with space current from the common source 13 and have a filament supply battery 48 connected in series with resistances 49, 50 and 51. Graded biasing potentials are available across the resistances 49, 50 and 51 upon the passage of filament current there-through. The grid of the first tube in circuit 43 is arranged to be biased by a potential including the potential drop across the three resistances 49, 50 and 51. The second tube is biased by the two resistances 49 and 50 and the third tube has its grid bias limited by resistance 49.

In the operation of the system shown in Fig. 3 the control current generated by main receiver 32 is normally sufficient, when applied to the circuit

circuit 43 by the amplifiers 39, 40 to maintain an operating current in the relay windings 70, 70 large enough to overcome the polarizing action of the windings 60, 60 and to cause the armature 45 to be held against contact 47. Receiver 33 is thereby normally short circuited and receiver 32 is connected through transformer 34 to the filter 35 and the telephone 36. Upon a slight falling off in the output of receiver 32 there is a corresponding decrease in the control current impressed upon the transformer 38. This current decrease, effective through the amplifiers 39 and 40 and the circuit 43 causes a disproportionately large decrease in the current supplied to the relay windings 70, 70. The relay armature 45 is immediately reversed by the action of the windings 60, 60, opening the contact 47 and closing the contact 46 to effect the desired switching operation. The result of the switching operation is to open the short circuit which is normally completed across the output of receiver 33 and to close a short circuit across the output of receiver 32. Receiver 33 is thereby connected to the filter 35 and receiver 36 in place of the main receiver 32. Upon restoration of the output of receiver 32 to its normal value, there is an increase in the control current resulting in another reversal of the relay 44, restoring the circuit to normal condition.

Tuned circuits 41 and 42 serve a double purpose of increasing the efficiency of the amplifiers 39 and 40 in the amplification of the control currents and of attenuating currents of the signal frequencies which may be impressed upon these amplifiers. The signal frequency currents, if transmitted through to the detecting circuit 43 in any substantial amounts, tend to cause rapid reversals of relay 44 which are troublesome.

In certain cases, the polarized relay 44 shown in Fig. 3 has been found preferable to the neutral relay R of Fig. 1, giving smoother operation free from chattering.

What is claimed is:

1. A space discharge detecting system comprising a plurality of similar space discharge tubes each polarized by a potential more than sufficient to block the space discharge in that tube, means for impressing thereon an input wave sufficient in amplitude to overcome the biasing potential in the first tube thereby releasing a space discharge therein, a plurality of tuned circuits connected to couple said tubes in cascade arrangement, and an indicating means actuated by the last tube in the series when said input wave is applied to the first tube.

2. A detecting system comprising a plurality of voltage amplifying tubes and tuned circuits connected alternately in cascade arrangement, each tube being polarized by a potential more than sufficient to block the space discharge therein, but each tube after the first having less polarizing potential than the preceding tube, a power amplifying tube connected to the output of said cascade arrangement of tubes and circuits, said power tube being polarized by a potential just sufficient to block the space discharge therein, and an indicating device connected in the output of said power tube.

3. A wave detector comprising a plurality of similar space discharge devices, a plurality of tuned circuits coupling said space discharge devices in cascade arrangement, the last of said space discharge devices in the series being polarized by a potential just sufficient to block the space discharge therein and the preceding dis-

charge devices being blocked by successively increasing potentials.

4. A wave detector comprising a plurality of three-electrode space discharge devices, a plurality of resonant circuits coupling said space discharge devices in cascade arrangement, a space current source connected to the anode of each of said discharge devices, and means for impressing polarizing potentials on the control electrodes of said devices, the polarizing potential of the last discharge device of the series being just sufficient to block the space discharge therein and the polarizing potentials of the preceding discharge devices in the series increasing successively towards the first device of the series.

5. A wave detector in accordance with claim 4 in which the polarizing potentials of the discharge devices have magnitudes respectively in accordance with the arithmetic series 1, 2, 3—counting from the last discharge device of the series.

6. A system for discriminating between alternating current waves of slightly different amplitudes comprising a plurality of amplifying space discharge devices, the last of said devices being polarized by a potential just sufficient to block the space discharge therein and the preceding discharge devices being blocked by potentials successively increasing toward the first device of the series and indicating means connected with the last device of the series.

7. A wave detecting system comprising a source of waves to be detected, a pair of resonant circuits tuned to a frequency somewhat higher than the frequency of the waves from said source, means adapted to be actuated by said source to impress a train of impulses upon one of said resonant circuits, and current limiting means inserted between said resonant circuits for transmitting to the second resonant circuit oscillations of nearly

constant amplitude during the impulse excitation of the first resonant circuit by said train of impulses.

8. In a switching system, a relay and means for actuating the same in response to a slight change in the amplitude of an alternating current wave comprising a plurality of amplifying space discharge devices, the last of said devices being polarized by a potential just sufficient to block the space discharge therein, and the preceding discharge devices being blocked by potentials successively increasing toward the first device of the series.

9. The method of detecting an alternating current which comprises employing the peaks of the alternating current wave for impulse excitation of an oscillatory circuit of a natural frequency higher than that of the said alternating current, forming said natural oscillations into a train of impulses of increased energy content with limitation of the maximum amplitude of said oscillations, employing said train of impulses to excite additional oscillatory circuits of the same natural frequency with further limitation of amplitude and increase of energy, and utilizing said oscillations to give an indication.

10. A space discharge detecting system comprising a plurality of similar space discharge devices, means for polarizing each of said devices by a potential more than sufficient to block the space discharge in that device, a plurality of tuned circuits coupling said devices in cascade arrangement, and an indicating means actuated by the last device in the series when an electromotive force resulting from an incoming wave is applied to the first device of the series.

RUSSELL S. OHL.