April 21, 1942. T. B. D. TERRONI 2,280,672

AUTOMATIC GAIN CONTROL

Filed Nov. 20, 1940

FIG. 1.

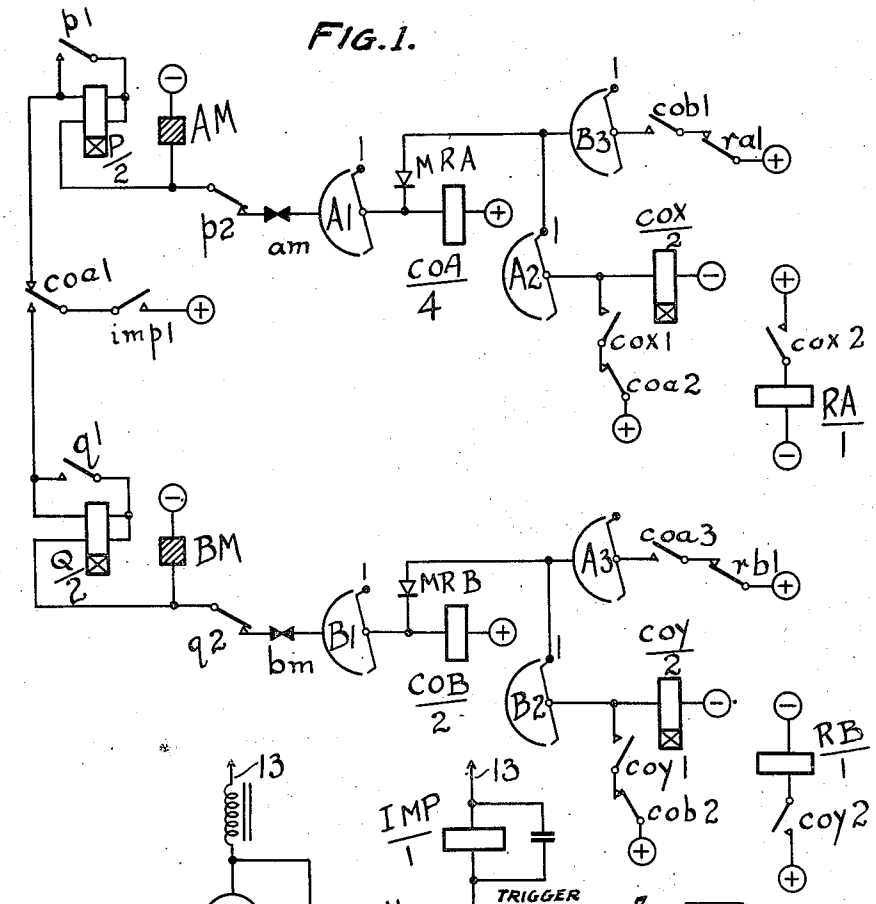
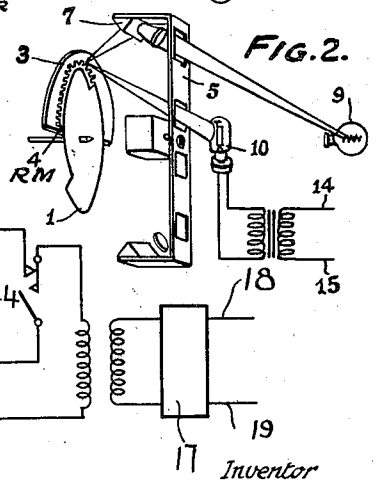


FIG. 2.



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per

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2,280,672

AUTOMATIC GAIN CONTROL

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6 Claims. (Cl. 178—44)

The present invention is concerned with improvements in or relating to carrier telephone and like carrier signalling systems, and is more particularly concerned with automatic gain control arrangements for use therein.

In systems of the above type it is the usual practice to employ at intermediate points and possibly also at terminal points, thermionic repeaters by means of which the received speech and/or signal energy is amplified before it is passed on along the line.

Under substantially constant conditions and for any given length of line, the gain of the various amplifiers can be set so that in spite of the line attenuation the received energy will be of the same value as the input energy at the transmitting end.

Due to variations in weather conditions and temperature, etc., the line attenuation does not remain constant and it is therefore necessary to introduce some form of gain control at the amplifier points. This can be done manually but this method is not very satisfactory in view of the fact that constant supervision is necessary to enable the gain to be readjusted each time line variations occur. It is the general object of the present invention to provide a simple and improved method of automatic gain control which employs only well tried components.

According to the invention, for the purpose of adjusting the gain of amplifier equipment in accordance with the line conditions a current of constant value and having a frequency which lies just outside, preferably in an unused portion of the carrier frequency range transmitted, is transmitted over the same medium as the carrier speech and/or signalling currents, the amplitude of the current at the point of reception or gain control serving to adjust the gain control in inverse ratio so as to maintain the strength of output current equal or in some other definite relation to the input current with varying line conditions. Conveniently the current is measured by means of a meter at each point at which automatic gain control is to be provided, the reading of the meter being scanned by a light ray and the arrangements are such that in accordance with the reading of the meter a number of impulses are generated which step a switch to a position connecting with one of a number of tappings on a gain control rheostat in such manner that the output energy transmitted from each amplifier station will remain at the pre-set value irrespective of variations in the input energy received thereat.

In order to prevent hunting of the gain control equipment, the scanning of the meter reading is arranged to be made at a slow speed and two setting switches are provided which respond alternatively to the series of pulses representative of the meter reading, a switch after having been set maintaining its position until the second switch has been set by the next series of impulses and then restoring to normal in readiness for a further series of impulses and so on.

The invention will be better understood from the following description of one method of carrying it into effect, reference being had to the accompanying drawing of which Fig. 1 shows schematically sufficient of the meter circuits and the gain control circuits to enable the invention to be readily understood; and Fig. 2 shows a known manner of associating the meter with the thermionic valve by which the gain control circuits are controlled and is substantially identical with the drawing of British specification No. 441,881.

Considering now the operation and referring to Fig. 1 of the drawing, a current having the frequency allotted to the pilot channel when received over the line conductors 10 and 11 passes through a filter F which is tuned thereto and causes a heavily damped meter movement RM such as that of a direct current ammeter in the anode circuit of a suitable detector valve D, which movement is shunted by the condenser 12 to take up a reading corresponding to the amplitude of the received pilot frequency current. In connection with this current it may be mentioned that the frequency of pilot channel will lie in the unused portion of the transmitter carrier frequency range, and the amplitude of the energy transmitted at the sending end will be maintained constant. The high tension supply to the anode of the valve D is completed from lead 13 via the inductance L and the meter RM.

As regards the meter RM, illustrated in more detail in Fig. 2, this will be of the so-called "photo-telemetering" type, the construction of which is known to those versed in the remote supervisory control art and the general form and operation of which is disclosed in our prior British specifications Nos. 441,881, 441,999 and 460,187. In these specifications are described arrangements by which meter readings are transmitted by optically scanning an electric meter by a rotary movement of a scanning device 5 and arranging that a light ray emanating from a lamp 9 and deflected by a prism 7 so as to be extended on to a photo-electric cell 10, and intermittently

interrupted by a comb 4 having non-reflecting teeth against a reflecting surfaced member 3 for a certain portion of the cycle, and opened for another portion of the cycle by a vane which is moved to correspond to the reading of the instrument. In the prior specifications the proportions of the two periods correspond to the reading of the meter but in the present arrangement use is made merely of the number of impulses produced in each series in accordance with the number of comb teeth and slots uncovered. These pulses which are generated by the photo-electric cell in response to the intermittent interruption of light rays extending thereto are communicated over leads 14 and 15 to a thermionic valve V which may be a vacuum tube of the trigger gas discharge type and in the anode circuit of which is connected a relay IMP.

Relay IMP in responding to one set of impulses steps a switch which will be designated as switch A to a corresponding position as a result of which a suitable tapping is selected on the gain control rheostat 16 via wiper and bank A4. On receipt of a second set of impulses corresponding to the next scanning operation, a switch which will be designated as switch B is set to a position corresponding thereto and switch A is honed and prepared to receive the next series of impulses. The switches A and B are of the electromagnetically operated reverse drive type, and are assumed for the purpose of the invention to have six positions, although of course in practice ten or more positions will be the more usual, in order that a finer adjustment of the amount of gain may be effected. Preferably the deflection of the meter RM will be approximately proportional to the strength of the pilot frequency current as measured in decibels above or below standard.

Considering now the circuit operation in more detail, it will be assumed that both switches A and B are in their normal positions 1 and hence when relay IMP responds to the first series of impulses, positive is extended over armature *imp1* to pulse the magnet AM of switch A, relay P operating on the first pulse and shortcircuiting one of its windings, so that by means of the short-circuiting effect in addition to that of its slug it will readily hold during the impulse train.

At the end of the series of impulses switch A will have been set to a position corresponding to the position of the meter pointer, and relay P will release after a short interval. At armature *p2* a circuit is now completed to operate relay COA over wiper and bank A1 in series with the magnet AM which will neither hold nor operate under this condition. Relay COA in operating at its armature *coa1* prepares a circuit to the magnet BM of switch B, at armature *coa3* completes an operating circuit over wiper A3 of switch A and normal contact and wiper B2 of switch B for relay COY and at armature *coa4* allows the incoming lines 10 and 11 to be connected up through the amplifier 17 to the outgoing lines 18 and 19 via wiper and bank A4 and a selected tapping on the gain control rheostat 16. Relay COY in operating locks over its armature *coy1* and operates relay RB to disconnect its initial energising circuit and to allow relay COB to be operated when the next series of impulses are received.

When the photo-telemeter performs a second scanning operation, a second series of pulses is delivered to relay IMP which in impulsing this time is effective on the magnet BM, relay Q holding operated during the train of impulses. At the end of the train relay Q releases and allows relay COB to operate in series with the magnet BM. Relay COB in operating at its armature *cob1* extends a positive over wiper and bank B3, metal rectifier MRA in a conductive direction, wiper and bank A1, magnet interrupter springs *am* of A switch and armature *p2* to complete a self-interrupted driving circuit for the magnet AM, whereupon the switch A is rotated to the home position 1 where the driving circuit is disconnected at the wiper and bank A1.

At the same time relay COA is short-circuited by the positive extended over armature *cob1* and releases so that the gain control is handed over to wiper and bank B4 over the normally closed springs associated with armature *coa4*. At armature *cob2* relay COY is released and in turn releases relay RB. When the A switch reaches the home position 1 relay COX is operated, locks and operates relay RA in order to remove the short circuit from relay COA in readiness for the third series of impulses.

In response to the third series of impulses relay A is once again set to a position corresponding to the position of the meter pointer and the operation will thereupon continue in the manner already described.

Circumstances leading to variation in the level of the received pilot frequency also bring about the same variations in the received carrier frequency level at an amplifier point in a connection, and at this point the apparatus according to the invention ensures that a corresponding inverse variation is made to the gain of the amplifier so that the output level is maintained constant irrespective of variations in the input level thereto.

I claim:

1. In a carrier-wave signalling system, a line, a filter connected to said line designed to pass currents having a frequency or frequencies close to but outside the frequency band of the carrier-waves, variably-responsive means controlled by current passing from the line through said filter, an amplifier connected to said line independently of said filter by which the carrier-waves are amplified, gain-controlling means for determining the gain of said amplifier, a second gain-controlling means for determining the gain of said amplifier and cyclically operated switching means for placing one gain-controlling means under the control of said variably-responsive means in inverse relationship to the strength of current flowing through said filter while the gain of said amplifier is controlled solely by said second gain controlling means.

2. In a carrier-wave signalling system a line, a filter connected to said line designed to pass currents having a frequency or frequencies close to but outside the frequency band of the carrier-waves, variably-responsive means controlled by current passing from the line through said filter, an amplifier connected to said line independently of said filter by which the carrier-waves are amplified, gain-controlling means for determining the gain of said amplifier, a second gain-controlling means for determining the gain of said amplifier, said gain-controlling means each including a device adapted to be variably set by said variably-responsive means and means for alternately placing one device solely under the control of said variably-responsive means while the other device determines the gain of said amplifier.

3. In a carrier-wave signalling system a line, a filter connected to said line designed to pass currents having a frequency or frequencies close to but outside the frequency band of the carrier-waves, a meter controlled by current passing from the line through said filter, an amplifier connected to said line independently of said filter by which the carrier-waves are amplified, a comb having teeth a variable number of which is exposed by said meter according to the current flowing through it, a light sensitive element, means for causing a ray of light to scan said teeth cyclically and cause the light sensitive element to generate pulses corresponding in number to the number of teeth exposed, a step-by-step switch including means for determining the gain of said amplifier arranged to be set by said pulses, a second step-by-step switch including means for determining the gain of said amplifier also arranged to be set by pulses from said scanning means, switching means whereby one step-by-step switch is alone connected up to control the gain of the amplifier while the other is being reset by pulses from said scanning means and controlling means responsive to the successive series of pulses generated by said light sensitive element to operate said step-by-step switches alternately and periodically to change the gain control to agree with that determined during the previous period.

4. In a carrier-wave signalling system, a line, a filter connected to said line designed to pass currents having a frequency or frequencies close to but outside the frequency band of the carrier waves, a meter variably responsive to the strength of current received from the line through the filter, an amplifier connected to said line independently of said filter by which the carrier waves are amplified, means for causing a light ray to periodically traverse the indicating face of said meter, means controlled by said meter through the medium of said light ray to cause the generation of impulses of current, a step-by-step switching device controlled by said impulse generating means to take up a position corresponding to the reading of said meter, and gain controlling means controlled by said step-by-step switching device.

5. In a carrier wave signalling system, a line, a filter connected to said line designed to pass currents having a frequency or frequencies close to but outside the frequency band of the carrier waves, a meter variably responsive to the strength of current received from the line through the filter, an amplifier connected to said line independently of said filter by which the carrier waves are amplified, means for causing a light ray to periodically traverse the indicating face of said meter, means controlled by said meter through the medium of said light ray to cause the generation of impulses of current, two step-by-step switching devices, means for causing said switching devices to be controlled alternately by said impulse generating means so that one is restored to normal and reset while the other remains operated, gain controlling means controlled by each switching device and switching means whereby the operated switching device is alone effective in determining the gain of said circuit.

6. In a carrier wave signalling system, a line, a filter connected to said line designed to pass currents having a frequency or frequencies close to but outside the frequency band of the carrier waves, a meter variably responsive to the strength of current received from the line through the filter, an amplifier connected to said line independently of said filter by which the carrier waves are amplified, means for causing a light ray to periodically traverse the indicating face of said meter, progressively-operated means controlled by said meter through the medium of said light rays to take up a position corresponding to the reading of said meter and gain-controlling means controlled by said progressively-operated means.

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