

Jan. 12, 1943.

W. T. DENTON ET AL

2,307,771

CARRIER CURRENT COMMUNICATION SYSTEM

Filed Jan. 16, 1940

2 Sheets-Sheet 1

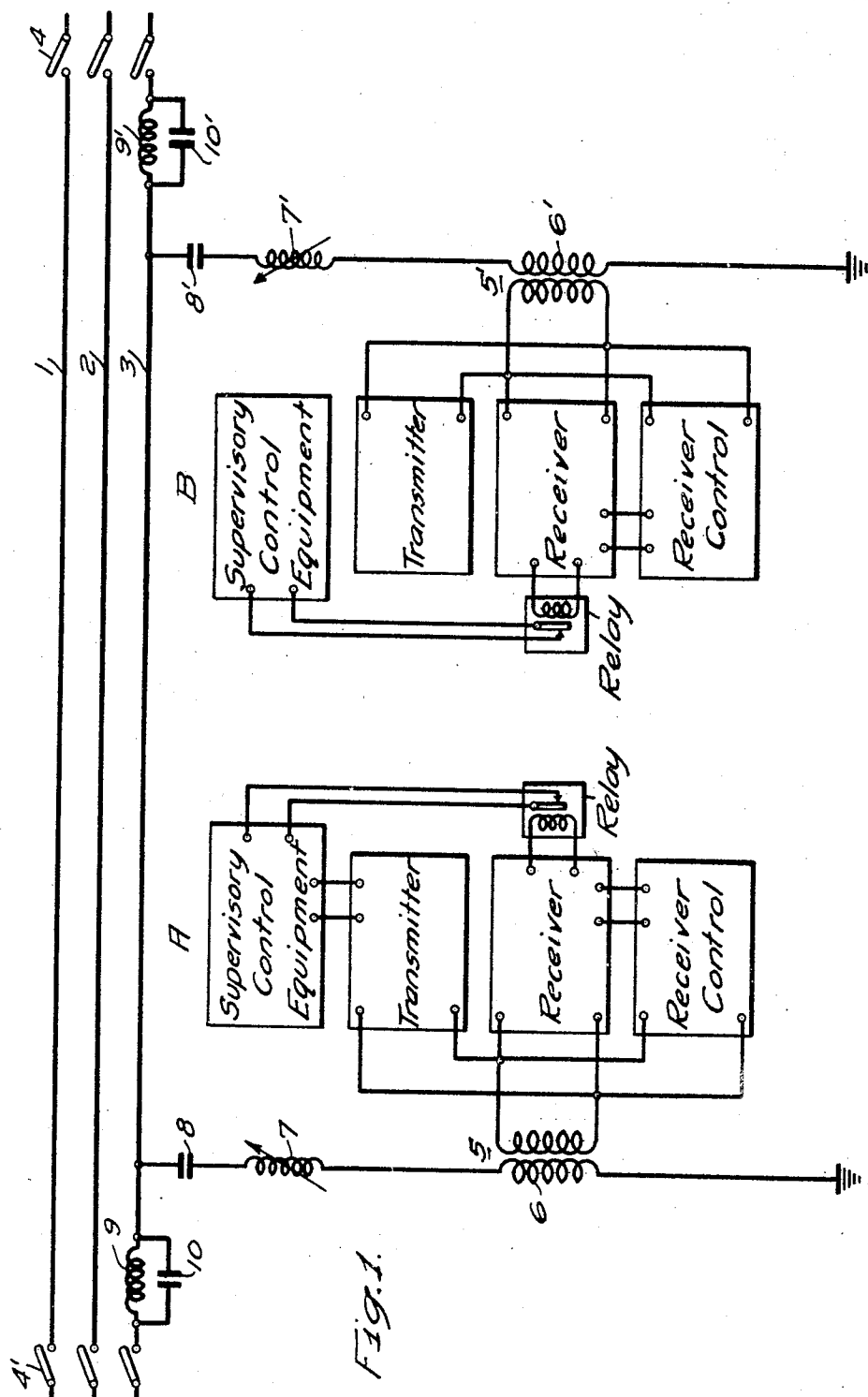


FIG. 1.

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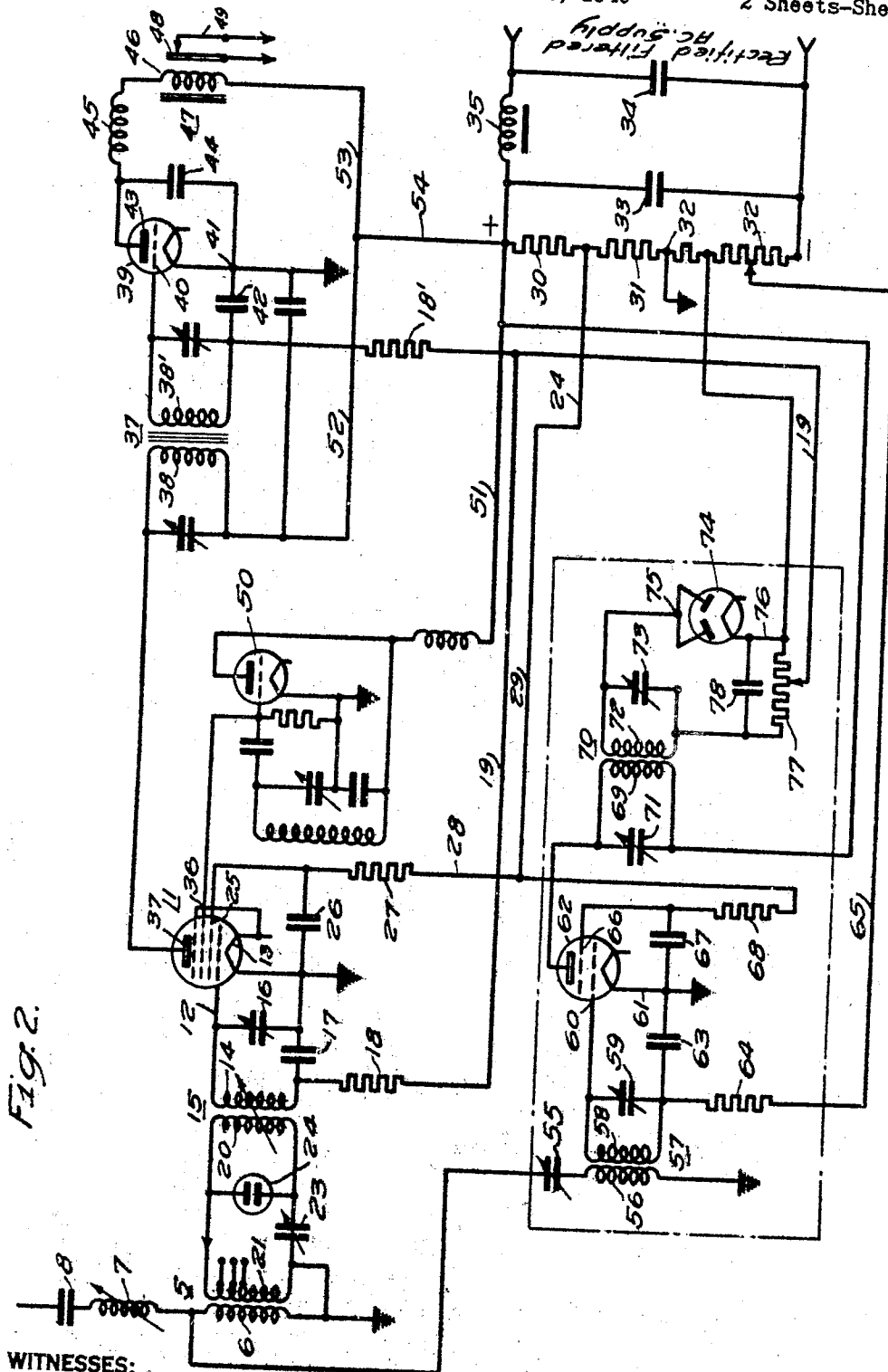


Fig. 2.

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CARRIER CURRENT COMMUNICATION
SYSTEM

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Application January 16, 1940, Serial No. 314,070

2 Claims. (Cl. 177-353)

This invention relates to carrier current communication systems and, more particularly, to systems of carrier current supervisory control distributed over power line circuits.

Supervisory control signals transmitted over power transmission lines make use of a carrier channel. Such a channel consists of semi-high frequency transmitters and receivers connected to the line through suitable coupling capacitors and tuning units. The supervisory control signals are converted into coded carrier frequency impulses.

In the operation of a system of the above type, it is extremely important that none other than the transmitted impulses shall actuate the control equipment which, in turn, operates the various circuit breakers and switches. Faulty operation due to signals originating from disturbances having frequency components within the signal frequency may cause serious damage and is often also a hazard to the safety of human lives. The disturbing signals may originate in the operation of disconnects and oil circuit breakers, atmospheric and lightning disturbances which propagate transients having steep wave front characteristics. Since these transient disturbances cover a wide range of frequencies, they include frequency components of the signal frequency channel to which the equipment is tuned, and create extraneous impulses which, being within the admittance band of the receivers, will cause operation of the receiver relay.

Lowering the sensitivity of the receivers to a degree of no response to such extraneous signals, as was customary in prior arrangements, has the disadvantage that the receiver will not operate on desired signals of small magnitude. Carrier frequency transmission over line conductors may vary within wide limits depending upon various factors of power line conditions. Therefore, it is necessary for successful reaying that the receivers maintain high sensitivity in order to respond to low levels of signal impulses also.

The particular feature of this invention is that the operation of carrier frequency receiving systems as to the desired signals is maintained with high receiver sensitivity at all times whereas the operation of the receivers is automatically suspended during the presence of interfering signals having frequency components within the admittance band of the receivers. To this end, means are provided for automatically disabling the receivers in the presence and for the duration of interfering signals and upon cessation of

these signals to reestablish the operation of the receivers at their full sensitivity.

Another feature of this invention is that the control operation is independent from the transmission level of the signal frequency being based upon the fact that the interference includes a wide band of frequencies whereby the control may be effected by any frequency which is outside of the signal channel. The response to frequencies other than the transmitted signal and the conversion thereof into a desensitizing factor is the function of the interference eliminator in accordance with the present invention.

A further advantage of the system herein described is the simple circuit arrangement which may easily be applied to various types of carrier current as well as radio broadcast receivers, the operation thereof being entirely automatic.

Other features and advantages will be apparent from the following description of the invention, pointed out in particularity by the appended claims and taken in connection with the accompanying drawings, in which:

Figure 1 is a schematic circuit showing in block diagrams a carrier current distribution system for supervisory control utilizing the interference elimination in accordance with this invention; and

Fig. 2 is a schematic circuit diagram of the interference eliminator applied to a standard type of carrier current receiver.

In Fig. 1, the carrier communication system is shown to include two stations, both having a transmitter and a receiver, the latter actuating the operation of the supervisory control equipment. This figure shows a simple installation, although depending upon the length of the power distribution network, a number of other transmitter and receiver stations may be used. For simplifying the illustration, only a straight portion of the power line is shown comprising conductors 1, 2 and 3 which may be any direct or alternating current system. Switches 4 and 4' are shown as an example of the type of equipment which is operated by the supervisory control equipment.

It is not believed necessary to show in detail the various circuits of the power distribution system, particularly the different type of switching operations which the supervisory control equipment is called upon to perform. The invention resides in the carrier current communication feature which is established between points A and B located along the power line. At the points between stations A and B, the transmitter and the

receiver are suitably coupled to the line by means of coupling transformer 5, the primary 6 of which connects through the loading inductance 7 and coupling capacitor 8 to line 3. The other terminal of the secondary winding is grounded and in this manner the circuit is completed between receivers and transmitters. A parallel resonant circuit comprising inductance 9 and capacitor 10 may be placed in series with line 3 preceding the point of coupling serving as a trap circuit for frequencies other than the carrier used for communication. The function of the transmitter is to send signal impulses and operate at a frequency band which may be called a semi-high frequency in the neighborhood of 60 kilocycles. The carrier frequency impulses sent out by the transmitter in a certain prearranged code are to be intercepted by receivers located at distant points, such as the one at station B, and vice versa, impulses sent by the transmitter located at other stations are to be received at station A by the receiver.

Response of the receiver to the carrier frequency signal results in actuation of the relay connected thereto which operates suitable circuits in the supervisory control equipment. Despite the insertion of filter networks shown schematically by the parallel tuned circuits 9 and 10, transient impulses originating from various sources in a power line system are disturbing in that when received by the receiver unwanted operation of the relay will result which causes actuation of the supervisory control equipment.

As stated before, these impulses have steep wave fronts and wide band frequency characteristics having frequency components within the admittance band of the receiver. Consequently tuned circuits, no matter how sharply resonant they may be, are inadequate alone. In order to eliminate the response to all frequencies including even the signal frequency when disturbances occur, it is necessary to control the effective operation of the receiver. This control is accomplished by means of a receiver control connected to the input circuit of the receiver to be energized by the extraneous impulses, the output of which is fed to a portion of the receiver in such manner as to produce a certain controlling effect upon circuit components. The receiver control is shown in block diagram as a separate unit in order to facilitate the understanding of its operation. It is to be understood, of course, that the receiver control may also be built into the receiver as an integral part thereof without departing from the essence of this invention. The equipment at station B is identical in every respect with that of station A and the coupling components are indicated by the same reference characters having primary indexes. The coupling of the various units to the line is shown by a single transformer in this figure merely to simplify the illustration. Each unit, such as the transmitter and the receiver, or the receiver control, may have separate coupling impedances of the type most suitable for its input circuit with the same result as can be obtained by the coupling shown herein.

The operation of the interference eliminator will be better understood by reference to Fig. 2, which shows schematically a standard receiver of the superheterodyne type comprising a mixer stage including vacuum tube 11. The input of the amplifier between grid 12 and cathode 13 thereof comprises the tuned circuit consisting of the secondary 14 of coupling transformer 15 and tuning

capacitor 16. Bypass condenser 17 is connected to the grid return circuit which continues through resistor 18 to a source of bias potential over conductor 19. The primary 20 of the transformer 15 is connected to the secondary winding 21 of the line coupling transformer 5. For maximum current transfer in the circuit, the secondary winding 21 has various taps and a tuning condenser 22 is serially interposed. A neon glow light 24 in shunt with the winding 20 acts as a limiter load for large voltage surges. The screen grid 25 of tube 11 is suitably by-passed by condenser 26 and filter resistor 27 and connects to a positive potential source through conductors 28 and 29. The source of operating potential herein shown by way of illustration is a conventional rectified and filtered alternating current power supply having a voltage divider in the form of resistors 30, 31, 32' and potentiometer 32. Filter condensers 33 and 34 and filter choke 35 are arranged in a conventional manner. Only part of the power supply circuit is shown, since all types of supplies may be used as long as the voltage and current characteristics thereof is suitable for the particular tubes in the circuit.

Continuing the description of the receiver, a local oscillator of the vacuum tube type is shown to supply high-frequency voltage to the mixer grid 36 of tube 11. The various components of the oscillator need not be described in detail, inasmuch as any type of high-frequency source may be used which can supply the required frequency in order to obtain the intermediate frequency to which the output circuit of tube 11 is tuned. The latter circuit, connected to the anode 37 of tube 11, includes the tuned primary winding 38 of an intermediate frequency transformer 37, the tuned secondary winding 39' thereof being connected to the input circuit of an amplifier tube 39 between grid 40 and cathode 41.

The grid return circuit is bypassed by condenser 42, filter resistance 43' and terminates at conductor 29, leading to the source of bias voltage which will be explained later. The output circuit connected to the anode 43 of tube 39 includes an intermediate frequency bypass capacitor 44 and choke coil 45, together with the energizing winding 46 of the relay 47. The contacts 48 and 49 of the relay 47 may be connected for the closure or opening of any desired circuit, such for example, as shown in Fig. 1, indicated as a supervisory control equipment. Anode potentials for both tubes 11 and 39 and also for the oscillator tube 50 are taken from the high potential side of the power supply through conductors 51, 52, 53 and 54.

The receiver circuit herein described is a simple superheterodyne generally employed for carrier current communication. Other types of receivers, for instance, tuned radio frequency circuits, of a suitable number of stages may be used. As long as the vacuum tubes utilized therein have such characteristics that cut off can be effected by a negative bias potential applied to a control element, the receiver control circuit, shown in dotted lines, in itself may be considered as a simple separate receiver having only a radio frequency amplifier and a rectifier. The input of the radio frequency amplifier is obtained through a coupling capacitor 55 and the primary 56 of the radio frequency transformer 57, both being connected effectively in parallel with the primary winding 6 of the coupling transformer 5. The control circuit is energized in this manner by the high frequency impulses from the power line in

the same way as the signal receiver. The secondary winding 58 of transformer 57 is parallel tuned with capacitor 59 and connects between grid 60 and cathode 61 of amplifier tube 62. The grid return circuit is bypassed by the capacitor 63 and returns through filter resistor 64 over conductor 65 to the center tap of the potentiometer 32 of the voltage divider circuit. The screen grid 66 of the amplifier tube 62 is connected through resistor 68 and conductor 29 in the usual manner to the screen potential tap of the voltage divider. The screen is also bypassed by capacitor 67. The anode of this tube is connected to the positive supply through a parallel resonant circuit consisting of the primary winding 69 of radio frequency transformer 70, the tuning being effected by condenser 71. The secondary 72 of this transformer is also tuned by means of condenser 73.

The voltage appearing in the secondary circuit is rectified by rectifier tube 74 which is in the form of a simple diode, the anode 75 therefor being connected to one terminal of the secondary winding 72 and the cathode 76 to the other terminal through a load resistance comprising potentiometer 77 which is bypassed by condenser 78. The slide of the potentiometer 77 is connected to the conductor 19 which terminates in the grid return circuits of the amplifier tubes in the signal receiver. The cathode 76 of the rectifier 74 is also connected to the junction point of voltage divider resistor 32'. The latter being at a potential more negative than ground supplies the necessary minimum bias through the load resistance 77 and conductor 19 for the grids of the amplifier tubes in the signal receiver.

In the operation of the system, the signal receiver circuits are carefully tuned to the selected signal frequency which, by way of example, may be 60 kilocycles. The circuit of the receiver control, however, is carefully tuned to a different frequency, usually slightly below the signal frequency, for example, to 55 k. c. It should be far enough removed from the signal frequency that the normal signalling will have no effect and should be close enough to easily pass the broad line tuning equipment. Frequencies slightly lower than the signalling frequency are usually used on the theory that the lower frequencies from remote disturbances will attenuate less and hence be more effective for this purpose. As long as there is only the carrier signal, the receiver control circuit receives practically no excitation due to its resonant characteristics and no signal is being amplified by the tube 62. Consequently, there is no signal to be rectified in the output circuit thereof. As long as the rectifier is inactive, there will be no voltage across the load resistor 77 and the bias for the control elements of the amplifier tubes in the signal receiver will be the normal required potential for maximum sensitivity of operation, this being derived from the voltage divider resistor 32'. As soon as transient impulses of any nature appear in the input circuits of the receiver as well as the receiver control, having frequency components beyond that of the signal frequency, by only a small amount, for example, 5 kilocycles, the control circuit will be energized and the particular component of the transient impulse frequencies amplified by the tube 62 and the resulting high frequency volt-

age rectified by the rectifier 74. The unidirectional component of this voltage appearing across the load resistance 77 will be additive to the minimum bias voltage and instantly provides a bias potential for the amplifier tubes in the signal receiver.

By suitable choice of circuit constants, a bias voltage proportional to the interference level can be obtained in this manner, having sufficient magnitude to completely block the operation of the amplifier tubes in the signal receiver and in this manner prevent the actuation of the relay 47. The amount of bias required may also be adjusted by the load resistance potentiometer, whereas the sensitivity of the control circuit can be adjusted by the potentiometer 32 in the voltage divider circuit.

In practical operation, this circuit was found extremely flexible and capable of delivering sufficient bias for disabling the signal receiver at even low levels of interfering transients. The tubes utilized in the receiver control giving satisfactory results were the type 77 for the radio frequency amplifier and the type 6H6 for the rectifier. The following values of circuit constants were found to give satisfactory results under actual operating conditions, and should be taken merely as a guidance since they must necessarily be varied to meet various conditions characterizing such installations.

The inductance value of the high-frequency transformers was approximately 15 microhenries and the coupling capacitor 55 was 250 micro-microfarads. The tuning condenser of the secondary winding 58 was approximately 70 micro-microfarads. The screen and grid return bypass capacitors were each $\frac{1}{10}$ microfarad. The radio frequency transformer coupling the rectifier had approximately the same characteristics as the input coupling transformer. The load resistance potentiometer 77 with approximately 20,000 ohms provided a bias voltage sufficient for blocking tubes 11 and 39.

We claim as our invention:

1. In a system of radio signalling primary receiving means responsive to a certain signal frequency, secondary receiving means responsive only to a particular other frequency adjacent to said signal frequency, a circuit interconnecting said receiving means including means for controlling the operation of said primary receiving means upon responsive energization of said secondary receiving means.

2. In a carrier frequency control system distributed over power lines, a signal frequency source, supervisory control equipment, a receiving arrangement comprising dual receivers one of which being tunable to a signal frequency is operable upon response for initiating the actuation of said supervisory control equipment and the other of said receivers being tunable to a frequency different from, but contiguous with, the frequency spectrum of said signal frequency, said latter receiver being operable upon energization to prevent the responsive action of said first receiver.

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