

April 4, 1944.

J. E. SMITH

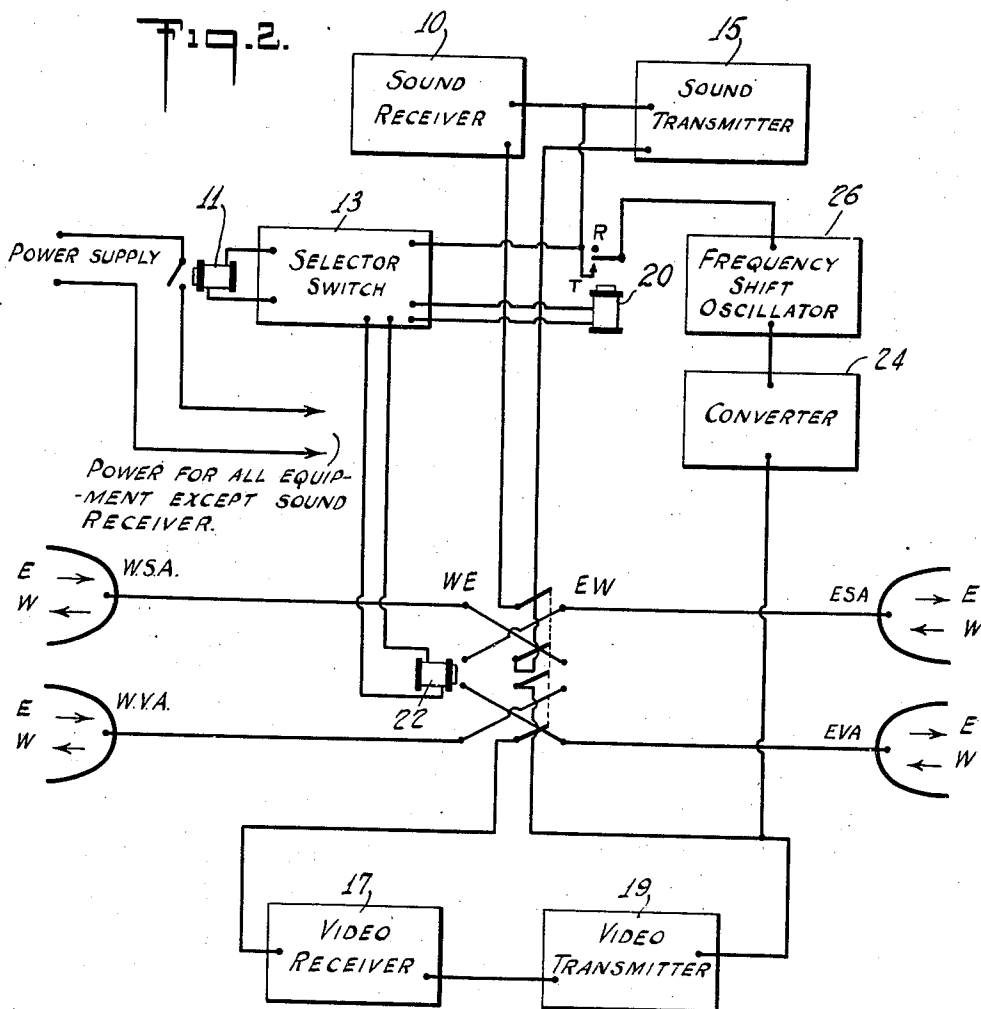
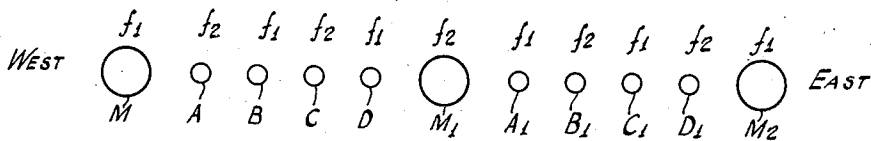
2,345,951

RADIO RELAY CONTROL SYSTEM

Filed March 19, 1942

2 Sheets-Sheet 1

Fig. 1.



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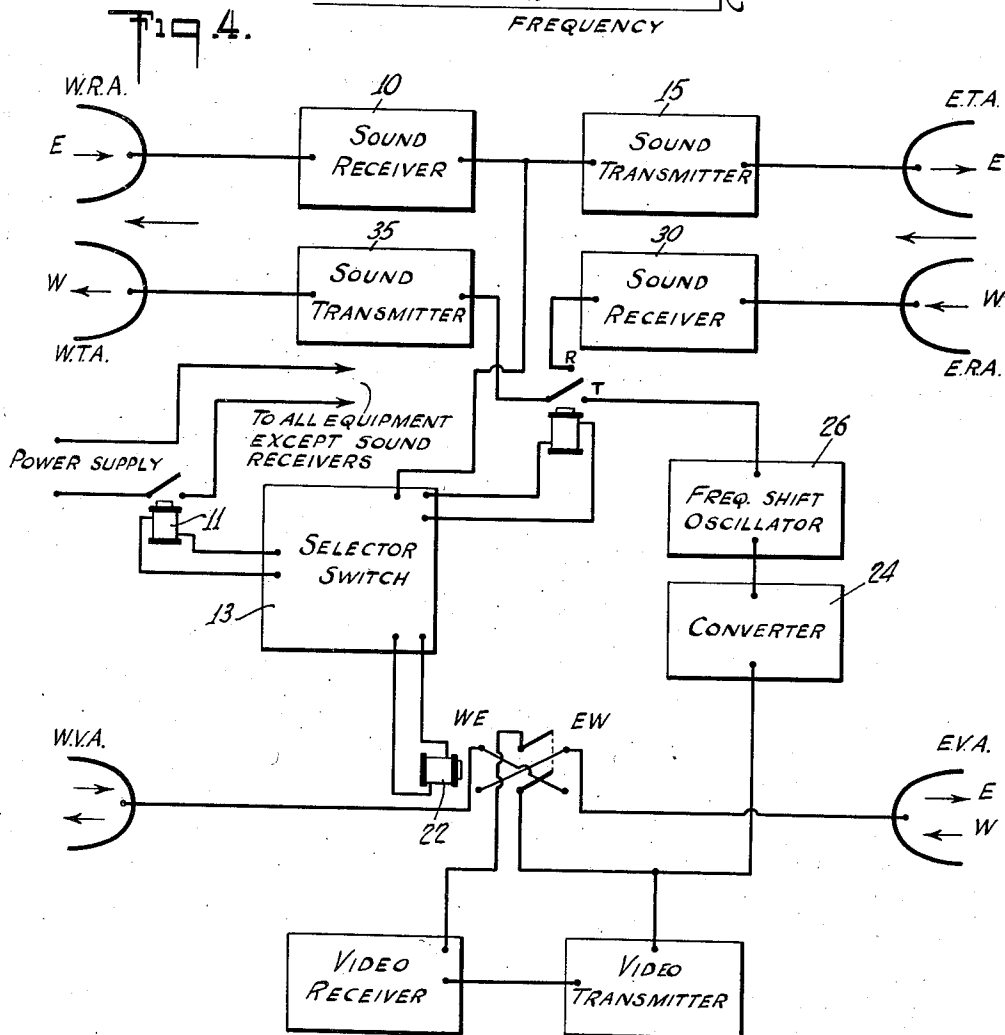
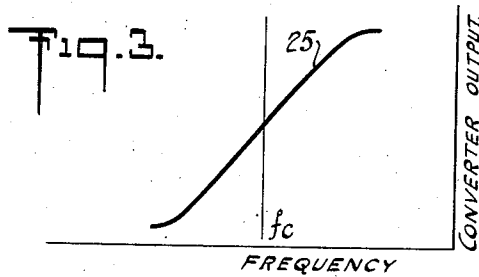
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2 Sheets-Sheet 2



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2,345,951

RADIO RELAY CONTROL SYSTEM

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Application March 19, 1942, Serial No. 435,271

7 Claims. (Cl. 250—15)

The present invention relates to radio relay systems and, more particularly, to organizations included in such systems for controlling and monitoring the operation of the component stations of the system. Radio relay systems operating in the neighborhood of 500 megacycles must be composed of a great number of individual repeater stations. In the present state of the art it is necessary for these individual repeater or booster stations to be spaced about 15 miles apart. It is desirable that most of these stations be unattended and automatic in operation. To operate this chain of relay stations satisfactorily, a control system must be incorporated by means of which the operation of the unattended stations may be initiated and concluded when desired and by means of which the manner of operation may be supervised or monitored from attended stations in the system.

An object, therefore, of the present invention is the provision of a radio relay system utilizing a minimum amount of control equipment.

Another object of the present invention is the provision of a method of and a means for monitoring the operation of repeater stations in a system, as aforesaid.

The foregoing objects, and others which may hereinafter appear, are attained by providing a relay system comprising a series of attended master stations separated by unattended satellite repeater stations.

In one embodiment of the present invention, each satellite station contains a main transmitter and receiver operating to relay one type of signals such as the video portion of a television signal, an ancillary transmitter and receiver operating to relay the associated sound portion of a television signal, as well as operating instructions and control systems. Each station also includes associated control and test equipment entirely operative from preceding and succeeding master stations by code impulses, such as generated by telephone dial equipment transmitted over the sound channel. It is contemplated that two carrier frequencies be alternated throughout the video channel and two similarly alternated carrier frequencies in the ancillary sound channel. This arrangement permits operation in either direction by merely reversing the transmitting and receiving antenna directivities without the necessity of returning the receivers and transmitters. It is assumed that the band width of the video transmitting and receiving antennas is sufficient to include each car-

rier and its associated side bands without frequency discrimination. Each master station of the system is arranged to perform the following functions with respect to each of its satellite unattended repeaters:

1. Start and stop the transmitting and receiving equipment;

2. Monitor the radio frequency output of each video transmitter;

3. Monitor the operation and power output of each video transmitter;

4. Reverse the direction of transmission of both video and sound channels.

In a modified form of the present invention it is contemplated that a two-way sound channel be used with separate receivers and transmitters for each channel at each relay station. Thus, the fourth operation listed above affects only the direction of operation of the video transmitter and receiver at each satellite station.

The present invention will be more fully understood from the following detailed description which is accompanied by drawings in which Figure 1 illustrates a representative layout of a relay system employing master and satellite stations and the relation of operating frequencies which may be used; Figure 2 illustrates, in conventional block diagram formation, one typical unattended station, while Figure 3 is a curve illustrating the operation of a portion of Figure 2, and Figure 4 illustrates a modification of the embodiment of Figure 2.

The relay system illustrated in Figure 1 consists of a master station M which may, for example, be assumed to be at the west end of the relay system. Extending in an eastward direction therefrom are located satellite repeater stations A, B, C, D. The stations have their video channels adjusted to operate on frequencies f_1 , f_2 , alternately. Thus the video receiver at A is required to receive signals of frequency f_1 from station M or station B and is also required to reject signals of frequency f_1 from station D. Since station A is at a distance from station D three times that from station B, the signals from station B will be much weaker and will be rejected due to the well-known discrimination of frequency modulation reception even though the stations are arranged in a straight line so that the characteristics of the antennae overlap. No difficulty attends the reception at station A of frequency f_1 from station M without interference from stations B, D, etc., also operating on frequency f_1 due to the employment of directional antenna structures at each station. A repeater

station typical of any of the stations A, B, C, D of Figure 1 is shown in Figure 2. The ancillary receiver 10 operates continuously so that any signal radiated at an immediately preceding station such as M and picked up by receiving antenna WSA will be applied to selector switch 13 associated with receiver 10, assuming, of course, that at that time the switch 22 is in the proper position. All of the other equipment at each satellite station is energized from the power supply source only when relay 11 is energized. If it is assumed that the relay system is to be placed into operation and the operating characteristics checked, the operator at the master station M dials, or otherwise transmits, a code combination which actuates selector switch 13 to the proper position to energize relay 11 thus starting the sound transmitter 15 and the video channel receiver and transmitter 17-19. The advantages of operating an entire chain of relay stations on two alternating frequencies f_1 and f_2 and structures for enabling such operation is disclosed and described in detail in my application, Serial #430,527, filed February 12, 1942, to which reference may be had if a more complete disclosure is desired. However, for the purposes of understanding the present invention, it is believed sufficient to merely assume that the relay stations are operated on two alternating frequencies f_1 and f_2 .

Once the sound transmitter is on the air, any further signalling impulses picked up by antenna WSA will be transmitted from sound transmitter 15 over the eastwardly directed antenna ESA, as indicated by arrow E at that antenna. Then the master station M, by transmitting further appropriate signal impulses, starts the succeeding satellite stations B, C, D in consecutive order. The master station M then notifies the operator at station M₁ over the sound channel that he is ready for a test of the equipment. The operator at the master station M then again contacts repeater station at D and by means of a proper selection of code signals sets switch 20 in position T and switch 22 in the west-to-east transmission direction, as indicated by reference character WE. Radio frequency excitation from video transmitter 19 then feeds antenna EVA and converter 24. The energy radiated from antenna EVA is received and utilized in receiver circuits at station M₁. The converter 24 combines a radio frequency discriminator circuit and amplitude detector. Frequency modulation or frequency deviation from a standard frequency is thereby converted into amplitude variations representative of the frequency deviation. Thus with no modulating signal applied to video transmitter 19 and rigid limiting in its output stage, a direct bias voltage is developed in converter 24 and applied to the frequency shift oscillator 26. The magnitude of the voltage is directly proportional to the carrier frequency of video transmitter 19 as shown by the curve 25 in Figure 3.

The frequency shift oscillator includes two radio frequency oscillators and a mixer in a conventional beat frequency oscillator circuit. One oscillator is tuned to a fixed radio frequency while the other has its resonant circuit shunted by a variable reactance tube. Thus variations in the modulator grid bias cause the beat note output of oscillator 26 to vary in accordance with the variations in frequency of transmitter 19. When the video transmitter 19 is unmodulated, the bias voltage from converter 24 produces a steady tone frequency modulation of the sound

transmitter 15. This is transmitted by way of antenna ESA to station M₁ where a chart is available showing the relation between the radio frequency with respect to the received tone frequency. Structure of the converter 24 and the frequency shift oscillator 26 may, if desired, be of the type shown in Peterson Patent #2,291,558, granted July 28, 1942, on application Serial No. 365,584, filed November 14, 1940.

The operator at master station M then applies a test signal to the video transmitter at that location. For example, this signal may be a 60 cycle square wave of some accurately known and predetermined amplitude. The amplitude of the signal received out of the monitor receiver at station M₁ is direct indication of the power output of the video channel from station M through each of the relay stations A, B, C, D. By observing the square wave signalling over the video channel on an oscilloscope, the operator at station M₁ may determine that the video receiver is operating normally. If the video signal is abnormal, each repeater station A, B, C, D must be separately tested to determine the location of the trouble. In the special case, for example, where the trouble is in the video channel at station D this will be evident when the relay system, including the stations up to and including station C, has been checked and determined to be properly operating, as hereinafter described. After the system has been put into operation and the operation of the video transmitter 19 at station C checked, as described, the operator at station M notifies the operator at station M₁ that he is ready for a report. To receive this report, the operator at station M sets switches 22 in the EW position at relay stations D, C, B and A in the order mentioned. The operator at the station M₁ then reverses his antenna switch manually and reports by sound channel to the operator at the master station M. The operator at station M₁ now has control of all the intermediate repeaters. Hence, after completing his report, he reverses the switches 22 at each of the satellite stations in the order A, B, C, D. When this has been done, station M again has control and can proceed to test repeater C by operating switch 20 to position T and with the operator at station M₁ monitoring the signal received over the sound channel. The direction of transmission is again reversed for the operator at station M₁ to report to station M. After the report is made the channel is again changed to its original direction of transmission. This process is continued until all repeaters and the video transmitters therein have been checked. The chain is then directed properly from west to east and all master stations may await further orders by way of the sound channel.

It should be noted that the antenna switch 22 has been shown by way of illustration as a relay operated tandem of two double pole, double-throw switches. In practice, if such switches are used, they should be of such type that their impedance is not greatly different from the impedance of the transmission lines into which they are connected to prevent the introduction of reflections and loss of power. If desired, the antenna switches may be replaced by a physically rotatable antenna arrangement. Furthermore, the directivity of the antennae may be reversed by properly phasing the connections of the antenna and feed lines connected thereto, as taught by N. E. Lindenblad in his prior

applications #339,468, filed June 8, 1940, and #338,177, filed May 31, 1940.

The modification shown in Figure 4 differs from that shown in Figure 2 in that at each station, one sound channel, including receiving antenna WRA, receiver 10, transmitter 15, and transmitting antenna ETA, is provided for transmitting in a west-to-east direction. A second sound channel operating in an east-to-west direction is provided including an eastwardly directed receiving antenna ERA, receiver 30, a transmitter 35, and a westwardly directed antenna WTA. This arrangement, providing a two-way sound channel, permits instantaneous and continuous communication between a pair of adjacent master stations without the necessity of reversing the direction of transmission of the video channel of each of the satellite stations A, B, C, D. The direction of transmission of the video channel is, as before, reversed by switch 22 operating under control of selector switch 13 actuated in response to control impulses over the sound channels. The operation of switch 20 for monitoring the frequency of operation of video transmitter 19 is as heretofore described, except that the monitoring tone is reverted to the preceding master station instead of being forwarded to the following station. Thus the time lost in making individual reports from station M₁ to station M for each intervening station A, B, C, D is avoided. As a matter of fact, the presence of an operator at station M is not necessary during the preliminary testing period.

While I have shown and particularly described several embodiments of my invention, it is to be distinctly understood that my invention is not limited thereto but that modifications within the scope of my invention may be made.

I claim:

1. The method of monitoring the operation of an unattended relay station which comprises generating at said station, in response to control signals from a preceding master station, an audio frequency oscillation having a frequency proportional to the frequency of operation of a transmitter at said relay station, receiving said oscillation at a succeeding master station and measuring the frequency of said oscillations.

2. The method of monitoring the operation of an unattended relay station which comprises generating at said station, in response to control signals from a preceding master station, an audio frequency oscillation having a frequency proportional to the frequency of operation of a transmitter at said relay station, receiving said oscillation at a succeeding master station, and measuring the frequency of said oscillations, frequency modulating said transmitter in response to square wave signals from said preceding master station, receiving at said succeeding master station the square wave frequency modulated wave from said transmitter, demodulating said received wave, and comparing said demodulated received wave with said received oscillations.

3. A relay system including a plurality of master stations and at least one unattended satellite station therebetween, each station including main transmitting and receiving equipment operative on one frequency and normally so arranged as to receive signals from one adjacent station and transmit signals to another adjacent station, ancillary transmitting and receiving equipment operative on another frequency, the ancillary receiving equipment at each of said satellite stations being continuously energized,

means responsive to control signals received by said ancillary receiving equipment for energizing the remaining equipment at said station, means responsive to further control signals for reversing the direction of transmission of signals, means at said satellite stations for generating an audio frequency oscillation having its frequency dependent upon the frequency of operation of the main transmitting equipment at said station and means responsive to control signals for applying said audio frequency oscillations to said ancillary transmitting equipment.

4. A relay system including a plurality of master stations and at least one unattended satellite station therebetween, each station including main transmitting and receiving equipment operative on one frequency, ancillary transmitting and receiving equipment operative on another frequency, said equipment being normally so arranged as to receive signals from one adjacent station and transmit signals to another adjacent station, the ancillary receiving equipment at each of said satellite stations being continuously energized, means responsive to control signals received by said ancillary receiving equipment for energizing the remaining equipment at said station, means responsive to further control signals for reversing the direction of transmission of signals, means at said satellite stations for generating an audio frequency oscillation having its frequency dependent upon the frequency of operation of the main transmitting equipment at said station, and means responsive to control signals for applying said audio frequency oscillations to said ancillary transmitting equipments.

5. A relay system including a plurality of master stations and at least one unattended satellite station therebetween, each station including main transmitting and receiving equipment operative on one frequency and so arranged as to receive signals from one adjacent station and transmit signals to another adjacent station, ancillary transmitting and receiving equipment operative on another frequency, and similarly arranged for transmission and reception, the ancillary receiving equipment at each of said satellite stations being continuously energized, means responsive to control signals received by said ancillary receiving equipment for energizing the remaining equipment at said station, means at said satellite stations for generating an audio frequency oscillation having its frequency dependent upon the frequency of operation of the main transmitting equipment at said station, and means responsive to control signals for applying said audio frequency oscillations to said ancillary transmitting equipment.

6. A relay system including a plurality of master stations and at least one unattended satellite station therebetween, each station including main transmitting and receiving equipment operative on one frequency, normally so arranged as to receive signals from one adjacent station and transmit signals to another adjacent station, first and second ancillary transmitting and receiving equipment operative on another frequency, each of said ancillary receivers and transmitters being arranged to receive and transmit signals to one of said adjacent stations, the ancillary receiving equipment at each of said satellite stations being continuously energized, means responsive to control signals received by said ancillary receiving equipment for energizing the remaining equipment at said station, means at said satellite stations for generating an audio

frequency oscillation having its frequency dependent upon the frequency of operation of the main transmitting equipment at said station, and means responsive to control signals for applying said audio frequency oscillations to said ancillary transmitting equipment.

7. A satellite radio relay station adapted for use in a relay system including a plurality of master stations and at least one unattended satellite station therebetween, said satellite station including main transmitting and receiving equipment operative on one frequency, normally so arranged as to receive signals from an adjacent station and transmit signals to another adjacent station, first and second ancillary transmitting and receiving equipment operative on another frequency, each of said ancillary receive-

ers and transmitters being arranged to receive and transmit signals to one of said adjacent stations, the ancillary receiving equipment at said satellite station being continuously energized, means responsive to control signals received by said ancillary receiving equipment for energizing the remaining equipment at said satellite station, means at said satellite station for generating an audio frequency oscillation having its frequency dependent upon the frequency of operation of the main transmitting equipment at said station, and means responsive to control signals for applying said audio frequency oscillations to said ancillary transmitting equipment.

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