

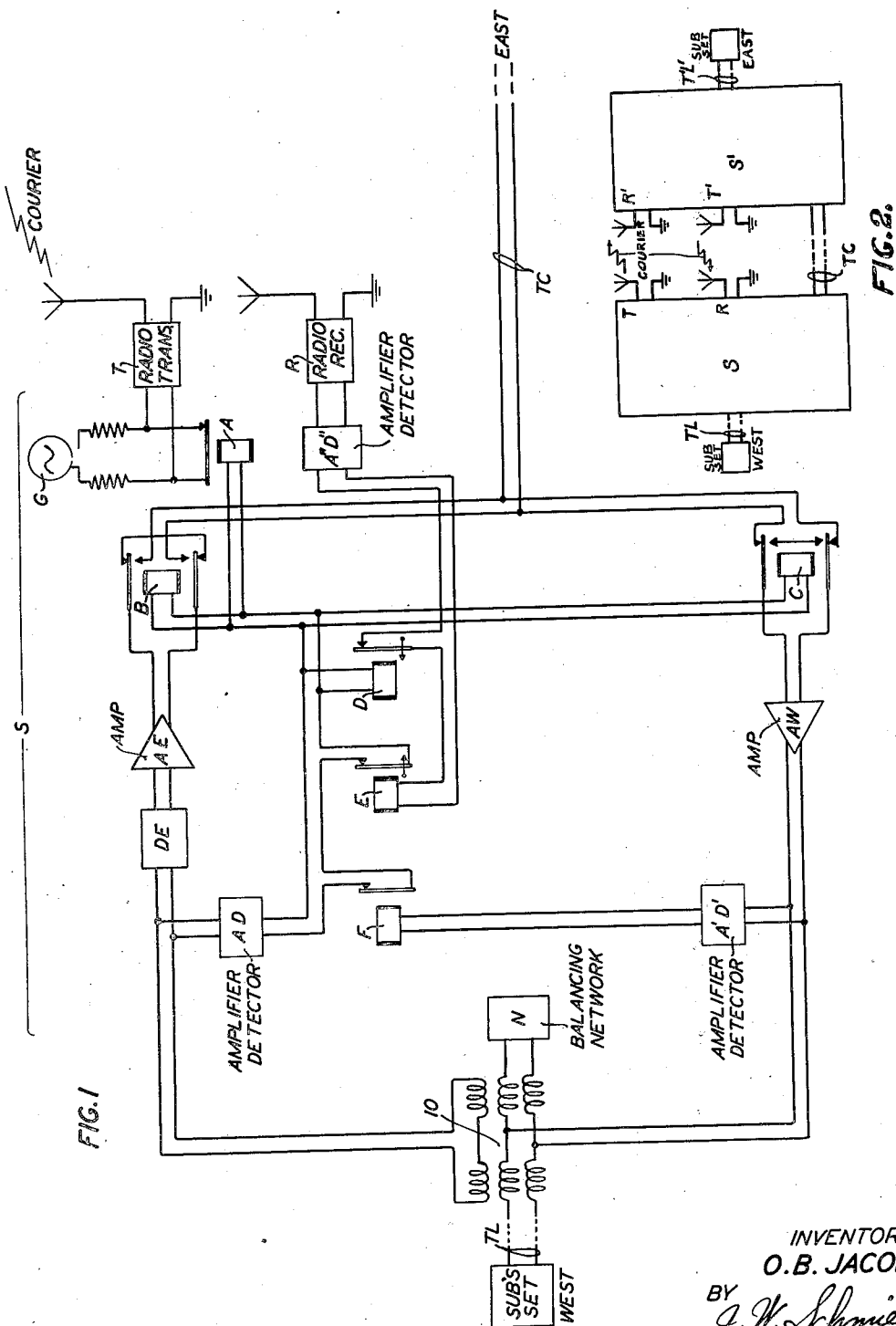
Dec. 11, 1934.

O. B. JACOBS

1,984,066

SIGNAL TRANSMISSION SYSTEM

Filed March 27, 1931



INVENTOR
O.B. JACOBS

BY *J. W. Schmier*
ATTORNEY

ATTORNEY

UNITED STATES PATENT OFFICE

1,984,066

SIGNAL TRANSMISSION SYSTEM

Oliver B. Jacobs, Morristown, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application March 27, 1931, Serial No. 525,644

5 Claims. (Cl. 178-44)

This invention relates to signal transmission systems and particularly to cable telephone systems which are electrically long.

An object of this invention is to minimize delays and hangover effects on telephone cable systems having large delays in transmission.

It is known in the art that, when a section of telephone transmission line has very great attenuation between adjacent repeaters, the magnitudes of the repeater amplifications required for satisfactory transmission are so great that it is impracticable to arrange the repeaters for two-way operation by the use of hybrid coils and balancing networks employed in ordinary two-way telephone repeater systems. In such case, when it is uneconomical to provide separate channels for the two directions of transmission, the single channel may be arranged to transmit signals in only one direction at a time. Such an arrangement requires the provision of apparatus and circuits to reverse the direction of transmission for which the terminal equipment is conditioned. In practice, the apparatus is controlled automatically either by the voice currents through the intermediary of amplifier detectors and associated relays or by so-called "courier" currents controlled by the voice currents at one terminal and transmitted to the other terminal where they act in the same manner to condition the distant end. U. S. patents to H. A. Barton 1,574,781, issued March 2, 1926; R. C. Mathes 1,678,188, issued July 24, 1928; and H. D. Arnold 1,565,302, issued December 15, 1925, disclose several such arrangements. These circuits employ either the same or the same type of electrical transmission path for both the apparatus-controlling current and for the speech current. Delay circuits are usually employed to delay the voice currents for an interval of time so that the courier current may proceed ahead of the voice currents to condition the distant repeater for transmitting the message waves in the proper direction before the voice currents arrive at that repeater. The courier current system is particularly adapted for use in systems wherein it is desired to insure that the terminal equipment at opposite ends of a long transmission line will not be conditioned for transmission in opposite directions at the same time. The condition just mentioned may occur in a system in which voice currents, originating at a station at or near one terminal of the system, are permitted to obtain full control of that terminal in the absence of speech currents arriving from the distant terminal. Under such conditions, speech currents from the talker's station at

the distant end of the connection may reach its adjacent terminal of the one-way line section and obtain control of that terminal before the speech currents from the first mentioned or nearby terminal arrive at the other terminal. This allows speech currents to be transmitted from both terminals simultaneously and prevents their reception at either end. Such a condition is termed "lock-out."

When an anti-lock-out courier current system is used, speech is delayed at the transmitting terminal and the equipment is left in the receiving condition (except during the short interval when the courier signal is being transmitted) until the courier signal has had time to be received at the distant terminal. Thus, if a courier signal has been transmitted from the distant terminal prior to the time when a similar signal was sent out by the nearby terminal, it will be received (unless it arrives just at the moment that the similar signal was being transmitted) and will take control of the nearby terminal. In this way, the possibility of lock-out is minimized.

Therefore, the use of the courier system as a means of minimizing lock-out involves delaying the speech currents for a time equal to the time of transmission of the one-way line section. This added time is required in each direction of transmission. The transmission time of certain types of line sections, having great attenuation between repeaters such as a transatlantic telephone cable, may be of the order of $\frac{1}{16}$ th of a second. The supplementary circuits from the line section terminals to the talkers' stations contribute additional delays which, in some cases, may add an equal or greater amount of delay to the circuit. Thus, even when a lock-out arrangement is used, the minimum length of time between the moment one talker ceases to speak and the moment when he can hear the beginning of the other talker's reply may be about $\frac{1}{8}$ th of a second. When an anti-lock-out arrangement is used, this time is increased by twice the transmission time of the one-way link, and therefore the total time may be as great as $\frac{1}{4}$ th of a second, or more in some cases. As the duration of the time of transmission is increased, each increment becomes progressively more objectionable from the standpoint of satisfactory telephone conversation. Thus, the delay which the anti-lock-out feature entails may be more undesirable than the delay which its use is intended to obviate.

In a system in accordance with this invention the controlling or courier current is transmitted

by radio, while the speech currents are transmitted over the cable line. The time of transmission for the radio circuit is much shorter than that of the cable circuit and, for this reason, the controlling current transmitted by radio will arrive at the distant repeater only a very short interval of time after the voice currents reach the repeater at the near terminal and, in any case, much ahead of the voice currents which arrive at the distant repeater. In this manner, the delay networks which are necessary for the proper functioning of the anti-lock-out type of courier circuit (which employs the same kind of electrical path for both the controlling current and the voice currents) may be made to have much smaller delays than otherwise and, in some cases, may be eliminated altogether. To obviate any difficulty due to atmospheric conditions, such as static, the same courier signal might be sent simultaneously on a plurality of radio channels to insure satisfactory reception of the signal. As an illustration, one band of frequencies 10,000 cycles wide would provide for the transmission of a large number of couriers, or could be used for one or a few couriers and the remainder of the band used for other purposes.

From a generic aspect, this invention comprises the use of a higher velocity channel for the controlling signal than that employed for the speech currents. The advantages of this invention are attained, to a degree at least, in the case of any high velocity channel. A system of this type is especially adapted for use in connection with a transoceanic submarine cable system in which the transmission time of the cable may cause difficulties in the operation of the system.

A modified form of this invention comprises the combination of ordinary voice-operated switching apparatus and apparatus responsive to courier current transmitted by radio for conditioning the circuit for proper transmission. In this manner, failure of the radio courier channels will not cause the telephone system to become inoperative.

A system arranged in accordance with this invention will now be described with reference to the drawing in which:

Fig. 1 represents one half of this system showing in detail the arrangement of apparatus at one terminal control station; and

Fig. 2 represents schematically this system as a whole.

In Fig. 1, a transmission line TC is illustrated having a terminal control station S which, in turn, is connected to a subscriber's set over a supplementary line circuit TL of an ordinary telephone system. TC may comprise any type of transmission line which is electrically long such as a submarine cable, or a long loaded land line.

The control station comprises essentially a repeater circuit having amplifiers AE and AW connected to the line section TL through hybrid coil 10, the line section being balanced by network N. It is to be understood, of course, that hybrid coil 10 and network N may be located at any distance from station S. A delay circuit or network DE is shown associated with amplifier AE. This circuit is made to have only such delay as is necessary to permit conditioning of the terminal apparatus before the voice currents arrive at the switching points. Bridged across the transmitting path and in front of DE is an echo suppressor unit AD. Similar echo suppressor units A'D' and A''D'' are bridged across the terminal receiving path and

across the radio courier receiving channel, respectively.

These echo suppressor units are of a type well known in the art, the detailed arrangement being illustrated in U. S. Patent 1,560,543, issued November 10, 1925 to G. Crisson and includes suitable vacuum tube amplifying and rectifying apparatus for rectifying the voice currents to operate relays. When voice currents are transmitted from west to east, the suppressor AD will actuate its relays A, B, C, and D in response to the voice currents. When voice currents are transmitted from east to west, the suppressor A'D' actuates its relay F to open the transmitting conditioning path. Similarly when courier currents are received by radio receiving station R, suppressor A''D'' actuates relay E to open up the transmitting conditioning path. Radio stations T and R respectively transmit and receive the radio courier currents. Radio transmitter T is designed to transmit a carrier frequency which is modulated by generator G and which may be any desired frequency or band of frequencies. Radio receiver R is designed to be sharply selective of the carrier frequency transmitted by the distant control station.

When the suppressor AD is actuated in response to voice currents transmitted from west to east, relay A is operated and its contact is opened. This removes the short circuit around the courier generator G which at once transmits oscillations of the frequency of the generator to radio transmitter T which, in turn, sends out a radio signal of the desired frequency. It is to be noted that the actuation of echo suppressor AD operates relay B to close the voice path to line TC, and also operates relays C and D to open the voice current receiving path and the radio courier current receiving path respectively.

Fig. 2 shows the system as a whole. It is to be understood that the circuits at the distant terminal station S' may be identical in construction to those at the nearby terminals. Consequently, the operation of the system as it affects only one of the terminal stations will be described.

Considering the circuit as a whole, voice currents transmitted from the west subscriber's station arrive at hybrid coil 10 and actuate suppressor AD causing the operation of relays A, B, C, and D. Relay A, upon operating, opens the short circuit around generator G and permits oscillations of the frequency of generator G to be transmitted to radio transmitter T for conditioning the control station S' at the distant terminal of cable TC to receive the voice currents transmitted over TC. The operation of switching relay B, it is to be noted, closes the path for the voice currents to enter cable TC, after passing through delay circuit DE and being amplified by amplifier AE. Relay C also operates at this time and opens the voice current receiving path at control station S. Its operation prevents the voice currents, transmitted by station S, from reentering the apparatus at terminal station S and interfering with the operation of the system. Relay D, opens the path controlled by suppressor A'D' and radio receiving station R. Consequently, any radio courier current transmitted by the distant terminal station S' after nearby terminal station S has started functioning, but before the courier transmitted by nearby terminal station S has had time to condition the apparatus at the distant terminal S', will be prevented from interfering with voice and courier current transmiss-

sion at the nearby station S unless it arrives before relay D operates. This relay D is designed to operate with a slight delay sufficient to permit the courier from the distant station S' to take control in case the distant station S' started to function before the nearby station S did. It is to be understood, of course, that relays A, B, C, and D may be designed to operate simultaneously or in any desired order in a manner well known in the art.

It will be recalled that the operation of relay A caused a courier current to be transmitted by radio transmitting station T. Coming now to the operation of the receiving apparatus at the distant terminal station S', radio receiving station R' at the distant station S' is made sharply selective of the frequency transmitted by T at the nearby station S and causes the operation of a suppressor at station S' which is similar to suppressor A'D' at station S. This suppressor at station S' actuates a quick operating relay also at station S' and which is comparable to relay E at station S. The operation of this relay at station S' opens the circuit leading from a suppressor comparable to suppressor AD and prevents the operation of relays similar to relays A, B, and C by the suppressor should the subscriber at the east subscriber's station begin talking at this time. The voice currents received at station S' over cable TC are amplified by an amplifier comparable to amplifier AW, pass through a hybrid coil similar to hybrid coil 10 and are received by the subscriber at the east subscriber's station.

If it is desired to insure proper conditioning of the system at the receiving terminal station S' in the event of failure of the radio courier channels, a combination of ordinary voice operated switching apparatus and apparatus responsive to courier current transmitted by radio may be used. In such case, suppressor A'D' and relay F may be inserted in the circuit as illustrated in the drawing. In this case a portion of the voice currents received and amplified by AW actuates suppressor A'D' which, in turn, causes the operation of relay F. The functioning of relay F opens the path leading to suppressor AD and prevents the transmission of currents in a manner identical with that hereinbefore described in connection with the operation of relay E by suppressor A'D'.

It is to be understood that this invention may be applied with suitable modifications to any system wherein a high velocity channel is employed for controlling the transmission of electrical energy carried by a slower velocity channel.

What is claimed is:

1. A two-way communication system comprising in combination a first terminal station and a second terminal station between which alternate transmission in opposite directions is to be had, a circuit connecting the terminal stations for transmission of signal currents, apparatus effective upon and controlled by the beginning of transmission of signal currents from the first terminal station to send courier current to condition apparatus at the second terminal station for reception of the signal currents, and instrumentalities for causing the courier current to arrive at the second terminal station before the arrival of the signal currents transmitted from the first terminal station, said instrumentalities including a radio link connecting the terminal stations and transmission apparatus for causing the courier current to traverse the radio link.

2. A two-way communication system comprising

in combination a plurality of terminal stations between which alternate transmission in opposite directions is to be had, a circuit connecting the terminal stations for transmission of signal currents, said circuit having—exclusive of any delay network—a definite transmission time, apparatus effective upon and controlled by the beginning of transmission of signal currents from one of the terminal stations to send courier current to condition apparatus at another terminal station for reception of the signal currents, a supplementary circuit connecting the terminal stations having—exclusive of any delay network—a transmission time shorter than said definite transmission time, and instrumentalities for causing the courier current to traverse the supplementary circuit.

3. A two-way communication system comprising in combination a first control station and a second control station between which alternate transmission in opposite directions is to be had, each of the control stations having a first terminal and a second terminal, a slow velocity transmission channel connecting the first terminals for transmission of signal currents, apparatus effective upon and controlled by the beginning of transmission of signal currents from the first control station to transmit courier current to condition apparatus at the second control station for reception of the signal currents, and instrumentalities for causing the courier current to arrive at the second control station before the arrival of the signal currents transmitted from the first control station, said instrumentalities including a high velocity transmission channel connecting the second terminals and transmission apparatus for causing the courier current to traverse the high velocity transmission channel.

4. A communication system comprising in combination a terminal station having a sending path and a receiving path, apparatus for sending signal currents over the sending path and out over a submarine cable to a second terminal station also having a sending path and a receiving path, apparatus at the first terminal station operating to disable the first receiving path in response to the transmission of signal currents over the first sending path, instrumentalities at the first terminal station for transmitting courier current over a radio link to the second terminal station, and apparatus at the second terminal station for disabling the second sending path, said apparatus being operated by the courier current received over the radio link.

5. A communication system comprising in combination a terminal station having a sending path and a receiving path, apparatus for sending signal currents over the sending path and out over a submarine cable to a second terminal station also having a sending path and a receiving path, apparatus at the first terminal station operating to disable the first receiving path in response to the transmission of signal currents over the first sending path, instrumentalities at the first terminal station for transmission courier current over a radio link to the second terminal station, apparatus at the second terminal station for disabling the second sending path, said apparatus being operated by the courier current received over the radio link, and additional apparatus at the second terminal station for further disabling the second sending path, said additional apparatus being operated by the signal currents received over the submarine cable.

OLIVER B. JACOBS.