

Nov. 3, 1942.

I. E. COLE ET AL
COMMUNICATION SYSTEM

2,300,775

Filed Aug. 31, 1940

6 Sheets-Sheet 1

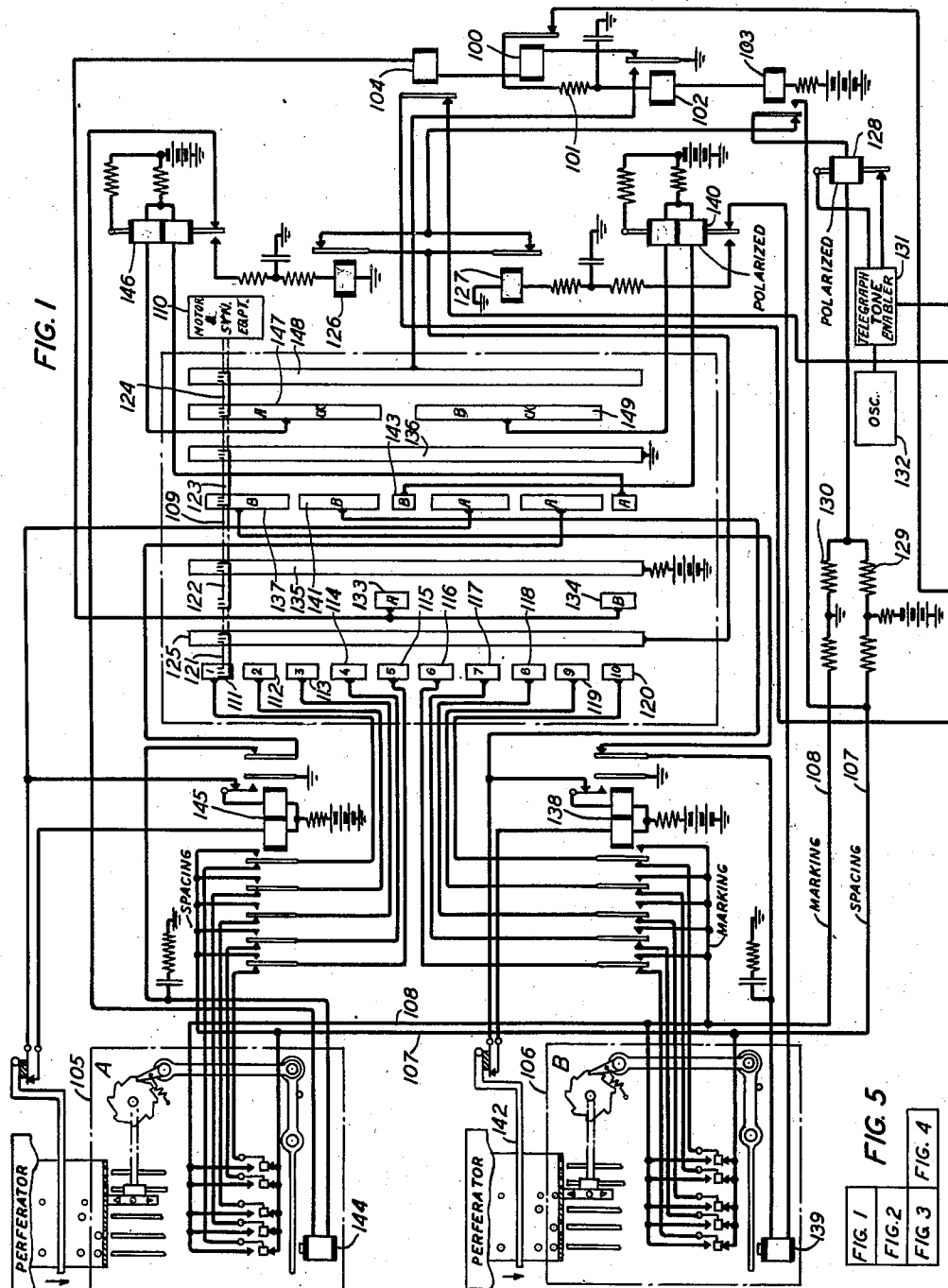


FIG. 1
FIG. 2
FIG. 3
FIG. 4
FIG. 5

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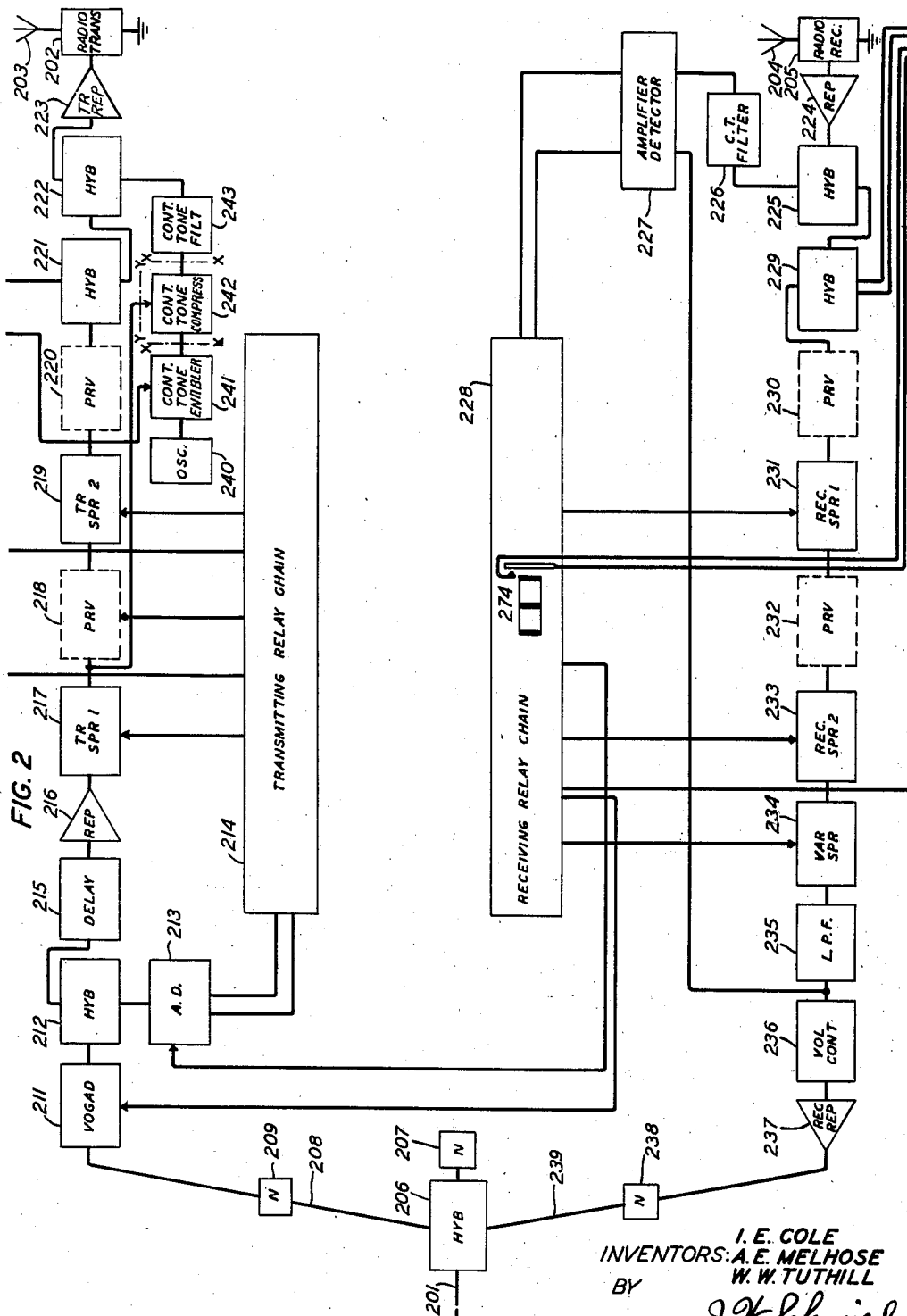
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6 Sheets-Sheet 2



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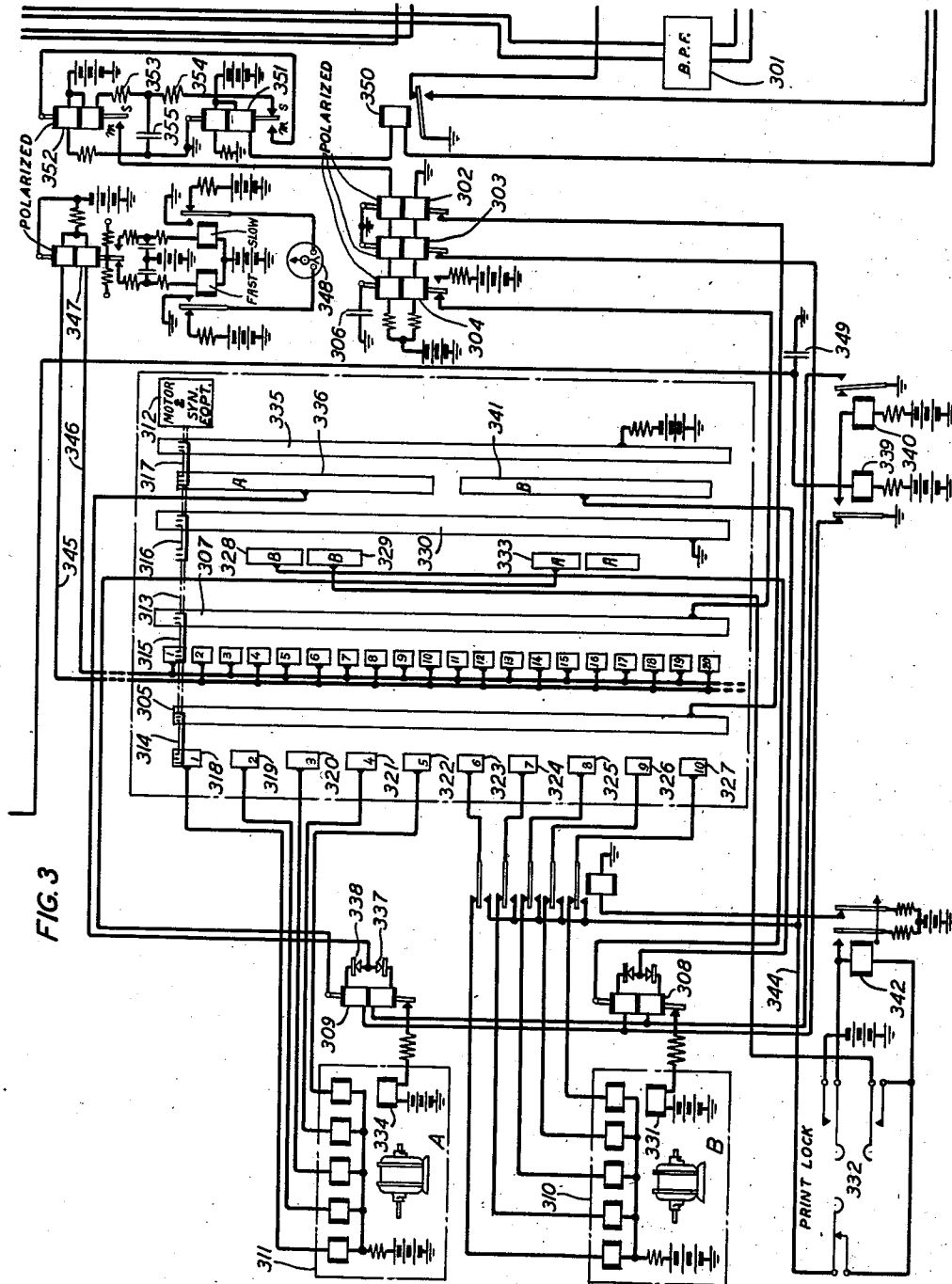
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6 Sheets-Sheet 3



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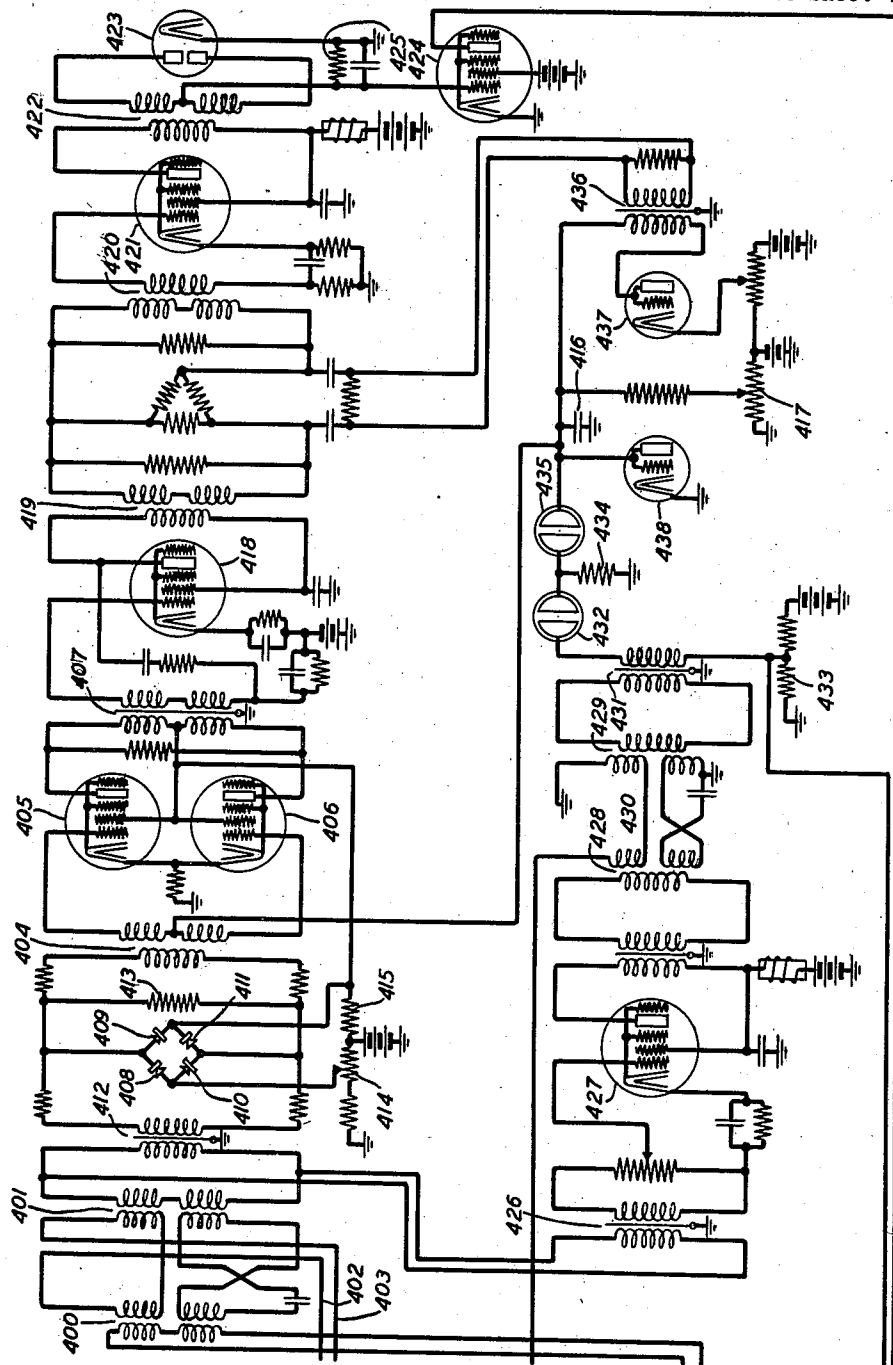
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6 Sheets-Sheet 4

FIG. 4



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I. E. COLE ET AL
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2,300,775

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6 Sheets-Sheet 5

FIG. 6

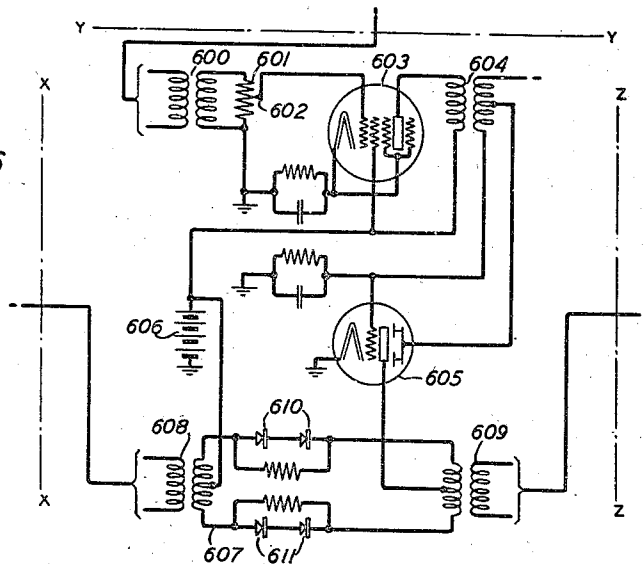


FIG. 7

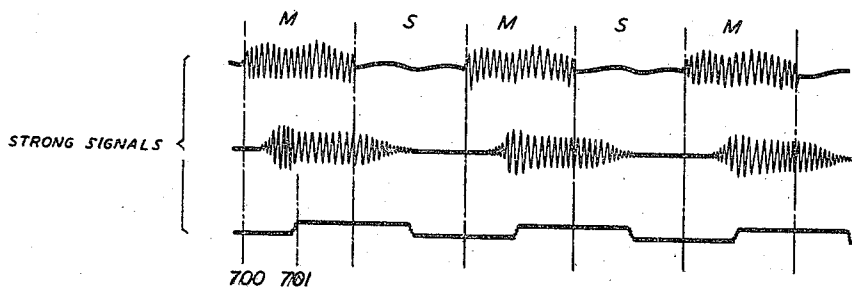
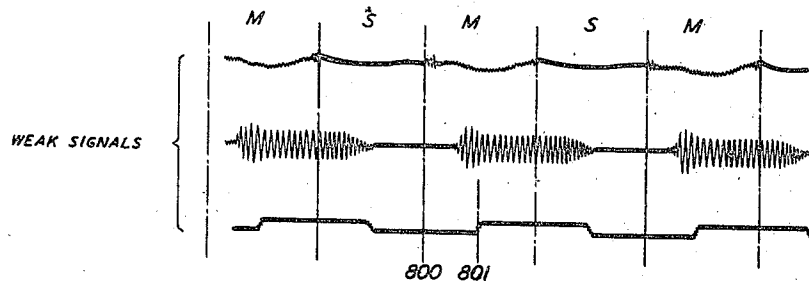


FIG. 8



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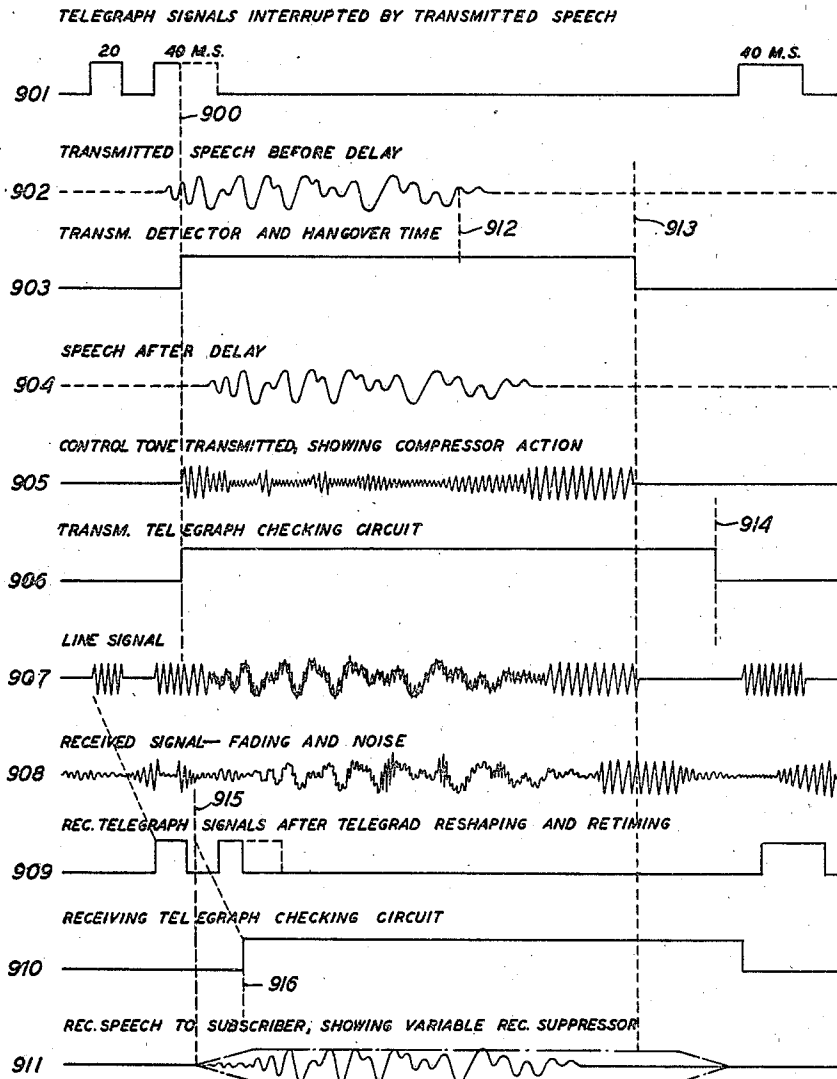
I. E. COLE ET AL
COMMUNICATION SYSTEM

2,300,775

Filed Aug. 31, 1940

6 Sheets-Sheet 6

FIG. 9



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UNITED STATES PATENT OFFICE

2,300,775

COMMUNICATION SYSTEM

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Application August 31, 1940, Serial No. 354,920

11 Claims. (Cl. 179—4)

This invention relates to communication systems and particularly to interpolated telegraph and speech systems wherein telegraph signals are interpolated in telephone conversations during lulls and pauses therein.

Where communication channels including suitable links are employed and where telegraph signals are transmitted in the form of voice frequency alternating currents a telegraph signal receiver known as a telegrad is employed. This device as fully disclosed in Patent 2,238,028, granted April 15, 1941, upon the application of Barney et al. has the characteristic of effectively delaying the telegraph signals passing there-through. A filter network having low attenuation to telegraph signal frequencies but high loss to all other currents is essentially a part of the telegraph receiving circuit and is included in the term telegrad. It is in this band-pass filter that the greater part of the time in transmission is lost.

Where the circuit into which the telegrad relays the telegraph signals must be controlled by the circuit over which the telegrad receives the signals, such control must be exercised in proper time relation to the flow of such signals. Therefore, a time delay comparable to the time delay caused by the telegrad must be introduced in the said control circuits.

In the specific embodiment of the present invention herein disclosed by way of example, the telegraph signals, delayed in passing through the telegrad, operate a printer. This printer has a separate control, the circuit for which must be kept closed to insure continuous operation. Particularly this circuit must be kept closed to insure the printing operation at the end of the selecting operation responsive to the signals from the telegrad. If this circuit is opened during the selecting operation, then the character being set up will not be printed and will be lost if not retransmitted.

The means for operating this separate control of the printer is a relay means operated from the transmission channel and not subject to the delay to which the telegrad subjects the telegraph signals. Therefore, it becomes important to prevent premature disabling of this separate printer control when the complete series of telegraph signals have been delivered to the telegrad but due to the delay have not been completely delivered by the telegrad to the printer, for such complete series of signals will be properly delivered and the printer should be allowed to complete its printing function. Since the complete

series has been delivered to the telegrad, the transmitting apparatus at the distant transmitting end will step to the next character and hence, if the printer at the receiving end is prevented from printing, such character will be lost and it will then be said that the telegraph message is mutilated.

The object of the present invention is to render switching operations in circuits including delaying telegraph relay circuits more accurate. This is of particular importance in the interpolated telegraph and speech system wherein the telegraph transmission must be interrupted whenever the voice currents take command of the transmission channel, for in such systems the greatest accuracy in switching from conditions suitable for telegraph transmission to conditions suitable for telephone transmission must be maintained. Since the voice currents may take command during the transmission of a series of telegraph signals representing a character code, such code must be completely relayed by the telegrad before the receiver controlled by the telegrad is disabled. This is of especial importance where the voice takes command near the end of the code for there special means are employed to insure the complete transmission of the code and hence the complete reception of the code must be insured, otherwise the message as printed may be mutilated.

A feature of the invention is a hang-over circuit for the control means operating the receiving circuit fed by the telegrad. By this means such control means, which is controlled simultaneously with the input of the telegrad, is caused to operate simultaneously with the output of the telegrad.

Another feature of the invention is a fast operating slow releasing relay for controlling the switching operations of a circuit operated by a telegrad.

Still another feature is a means for insuring the complete printing operation of a printer when the complete series of signals for a character have been delivered to a delaying telegraph signal relay.

The drawings consist of six sheets containing Figs. 1 to 9, inclusive. Figs. 1 to 4, when placed together as indicated in Fig. 5, show a circuit diagram partly schematic, of one terminal of an interpolated telephone and telegraph system.

Fig. 1 shows the transmitting telegraph circuits;

Fig. 2, partly schematic and partly circuit dia-

gram, shows the telephone and controlling circuits;

Fig. 3 shows the receiving telegraph circuits;

Fig. 4 is a detailed circuit diagram of the major portion of the telegrad, a telegraph gain regulating amplifier detector;

Fig. 5 on the same sheet with Fig. 1 shows how Figs. 1, 2, 3 and 4 are to be placed;

Fig. 6 is a detailed circuit arrangement of the control tone compressor indicated by the rectangle 242 in Fig. 2 and fitted into the general diagram of Fig. 2 at the broken lines X—X, Y—Y and Z—Z;

Figs. 7 and 8 are explanatory diagrams illustrating the transition of a signal in the telegrad from an alternating current varying strength signal to a direct current uniform strength signal. These diagrams particularly show the displacement in time between the input and output signals. Fig. 7 shows a strong input signal and Fig. 8 shows a weak input signal; and

Fig. 9 is another explanatory diagram showing the timing relation of the switching means employed in the present invention.

One terminal of a system is shown but it will be understood that at some distant point a similar terminal is located so that speech coming in over channel 201 will be transmitted from the radio transmitter 202 and its antenna 203 to be received at the said distant point over the antenna 204 and the radio receiver 205 for transmission into the speech path at that point corresponding to the channel 201.

While speech is being transmitted from channel 201 over the antenna 203, the telegraph transmitting apparatus of Fig. 1 is inactive and the telegraph receiving apparatus of Fig. 3 at the distant point is similarly inactive. By the same token the telegraph transmitting apparatus of Fig. 1 at the distant point and the telegraph receiving apparatus of Fig. 3 at the near end, as shown, will be in operation.

In general, speech over channel 201 enters the hybrid coil 206 provided with the usual balancing network 207, passes over path 208 through the network 209 to the voice operated gain adjusting device (termed vogad for short) 211. From the vogad 211 speech currents enter the hybrid coil 212 where they split, part going on to the main speech channel and part entering the syllabic amplifier-detector 213 for control purposes. The output of the amplifier-detector 213 feeds into the transmitting chain 214 which performs a variety of switching functions, as will be more clearly set forth hereinafter. At present it is sufficient to say that the transmitting chain 214 clears the way for the speech currents to the antenna 203 and that the distant receiving terminal similarly conditions the receiving circuits thereat for the proper reception of the speech currents. The main portion of the speech currents then pass from the hybrid coil 212 into the delay circuit 215, through a repeater 216, and the first transmitting suppressor 217. Thereafter the speech path is through privacy circuit 218, the second transmitting suppressor 219, and another part of the privacy circuit 220 to the hybrid coil 221. Speech currents then pass to the hybrid coil 222, thence to the transmitting repeater 223 to the radio transmitter 202.

At the distant receiving end the speech currents transmitted from the radio receiver pass through the receiving repeater 224 into the hybrid coil 225. At this point the control tone which accompanies speech is diverted to the control tone

filter 226, to the receiving detector 227, which operates the receiving chain 228. This receiving chain responds to the control tone transmitted from the distant end through the operation of the transmitting chain 214 thereat and like the transmitting chain performs a variety of switching functions which will be more fully described hereinafter. At present it is sufficient to say that the receiving chain clears the way for the speech currents to reach the hybrid coil 206 and channel 201. The speech currents leaving the hybrid coil 225 enter the next hybrid coil 229 and thence pass through a part of the privacy circuit 230, the first receiving suppressor 231, another part of the privacy circuit 232 to the second receiving suppressor 233. From this point the speech currents pass through the variable suppressor 234, a low-pass filter 235, a volume controller 236, a repeater 237, a network 238, and thence to the hybrid coil 206 from which they pass over the channel such as 201 at the said distant terminal.

The functions of these various pieces of apparatus are briefly as follows.

Referring to the details of the speech control circuits, the hybrid coil 206 receives voice currents from the channel 201 and transmits them out over the channel 208. The hybrid coil 206 also receives voice currents from channel 239 and transmits them out over channel 201. Actually the voice currents split equally to paths 208 and 239 but are prevented from passing over 239 beyond the repeater 237 by the unidirectional characteristics of this repeater. The function of the balancing network 207 is well known. In this connection it should also be noted that each of the hybrid coils 212, 221, 222, 225 and 229 are provided with appropriate balancing networks. The networks 209 and 238 are provided to perform certain functions necessary in commercial telephone circuits to compensate for the differences in transmission when the channel 201 is connected to different types of telephone circuits. Their adjusting circuits are not shown but they are included in the schematic part of this diagram in order to render the diagram as complete as possible. The vogad 211 is a means for adjusting the gain applied to the voice currents incoming thereto so as to provide a uniform level of output. The hybrid coil 212 allows a small part of the voice currents to be taken off to the syllabic amplifier-detector 213 without causing distortion in the voice currents flowing from the hybrid coil 212 to the rest of the circuit. The delay circuit 215 is an arrangement by which voice currents are delayed to allow time for the transmitting chain 211 to properly perform its functions before the voice currents are finally delivered to the antenna 203. Since these delay circuits entail a certain loss in transmission, amplifying means are associated therewith in the form of a repeater 216 which is shown as a one-way amplifying repeater. The first transmitting suppressor 217 and the second transmitting suppressor 219 both act to block speech currents therethrough when the relays of the transmitting chain 214 are in the position shown. When, however, the transmitting chain is operated both transmitting suppressor 217 and transmitting suppressor 219 give a clear path for the transmission of voice currents. It is necessary to use a blocking path at each terminal of the privacy system circuit 218, this being a controlling agency for the other part of the privacy system 220. These two units 218 and 220 are included to render the speech between the antenna 203 and

the distant antenna 204 unintelligible but do not form any essential part of the present invention being included again for the purpose of rendering the schematic layout as complete as possible. The function of the hybrid coil 221 is to transmit to the hybrid coil 222 either speech coming from the privacy system unit 220 or telegraph signals coming from Fig. 1 above. The function of the hybrid coil 222 is to pass on to the transmitting repeater 223 both the output of the hybrid coil 221 and the control tone originating from the oscillator 240. This oscillator is a source of alternating current of a frequency just outside the voice range so that it may be effectually filtered out at the receiving end without disturbing the voice currents entering the receiving circuit thereat.

Current from the oscillator 240 enters the control tone enabler 241, which is under control of the transmitting chain 214, as will appear hereinafter. When the voice takes command of the transmitting chain 214 and certain relays in the telegraph transmitting apparatus of Fig. 1 are properly operated, the control tone enabler 241 will allow alternating current from the source 240 to enter the control tone compressor 242 and from this point the control tone will be passed through the filter 243 to the hybrid coil 222. The effect, therefore, is that when the voice takes command of the transmitting chain 214, control tone at full volume will be delivered to the hybrid coil 222. A short time thereafter, as measured by the delay circuit 215 and controlled by a connection in the voice path between the first transmitting suppressor 217 and the first unit of the privacy system 218, the control tone compressor will operate to reduce the volume of the control tone being delivered to the hybrid coil 222.

The transmitting repeater 223 is a well-known type of one-way amplifier. The radio transmitter 202 and its associated antenna 203 need no special description. Likewise, the radio receiver 205 and its associated antenna 204 need no special description. The repeater 224 is, like the repeaters 216 and 223, a one-way amplifying device. The hybrid coil 225 receives the output of the radio receiver 205 and allows part of this output to flow to the control tone filter 226 which delivers to the receiving detector 227 only the control tone.

The hybrid coil 225 also delivers to the next hybrid coil 229 the speech currents, the accompanying control tone being filtered out later. Hybrid coil 229 acts during the transmission of speech currents to deliver the speech currents which are transmitted from the radio receiver 205 to the privacy system unit 230 and the various circuit units thereafter. During intervals of telegraph transmission the hybrid coil 229 delivers the output of the radio receiver 205 to the telegraph receiving apparatus of Fig. 3.

The privacy system units 230 and 232, like the privacy system units 220 and 218, are used to insure secrecy in the transmission of intelligence by translating for delivery to channel 201 the otherwise unintelligible transmission from the antenna 203 to the antenna 204. The first receiving suppressor 231 and the second receiving suppressor 233, which both operate under control of the receiving chain 228, operate to block the speech path during those intervals when the control tone is absent from the transmission being received by the receiver 205. When control tone is present as an indication that speech is pres-

ent, the receiving chain 228 is operated and the receiving suppressors 231 and 233 give a clear path for speech currents toward the hybrid coil 206 and the channel 201. The variable suppressor 234 is a device used to cause the transition from speech to silence and from silence to speech to be slow so that clicks and unpleasant operation of the circuit will not disturb the listener. The low-pass filter 235 effectually blocks any control tone which may have accompanied speech to this point and allows only the speech to go into the volume controller 236.

At this point it should be noted that between the low-pass filter 235 and the volume controller 236 there is a connection to the receiving detector 227. Thus when the voice takes command at the distant transmitting end, control tone from the oscillator 240 is transmitted by the radio transmitter at full volume, and this will enter the control tone filter 226 and the receiving detector 227 to insure the proper operation of the receiving master relay within the receiving chain 228. By the time that the voice arrives the receiving chain will have conditioned the receiving circuit, particularly by operating the first and second receiving suppressors 231 and 233 and the variable suppressor 234 so that as the control tone is reduced in volume through the action of the control tone compressor 242, voice currents from the connection between the low-pass filters 235 and 236 will reach the receiving detector 227 to augment the operation of this device and insure the proper and continuous operation of the receiving chain even during periods when fading or other disturbances in the mutable link cause the received control tone to drop to a value where the continued operation of the receiving chain might be unsatisfactory.

The circuit diagram of Fig. 6 shows in detail the control tone compressor 242. The single lines crossing the broken lines X—X, Y—Y and Z—Z represent a pair of circuit conductors as indicated in Fig. 6. Thus the single line crossing the broken line Y—Y represents a speech path entering the control tone compressor and connecting to the primary winding of the transformer 600. The secondary winding of this transformer connects to a potentiometer 601 having an adjustable point 602 which may be moved to different positions for adjusting the sensitivity of the device. From the potentiometer point 602 a well-known type of pentode amplifier tube 603 is controlled. The plate circuit of this tube feeds into an interstage transformer 604 which in turn feeds the amplifier speech currents into a double diode triode tube 605. The diode portion of this tube acts as a rectifier and the triode portion acts as an amplifier. Thus the speech currents entering the transformer 600 are transformed into a varying strength direct current corresponding to the strength of the speech currents. The plate circuit of the tube 605 may be traced from battery 606 and thence through two parallel paths in the varistor 607 to the plate of tube 605. The varistor 607 is a variable loss device the loss value of which is controlled by the direct current flowing in the plate circuit of tube 605.

The line crossing the broken line X—X represents a circuit from the control tone enabler 241 and the line crossing the broken line Z—Z represents a path leading into the control tone filter 243. The control tone, therefore, enters the primary of a transformer 608, passes through the varistor 607 and enters the transformer 609.

which feeds into the control tone filter 243. Under the condition where no speech currents are entering the transformer 600 the loss of the varistor 607 is low, the alternating current from the source 240 passing easily through the copper oxide rectifiers 610 and 611. When the volume of speech entering the transformer 600 is low, the current flow in the plate circuit of tube 605 affects the copper oxide rectifiers 610 and 611 so as to introduce a certain amount of loss in the control tone path. Speech of greater volume will correspondingly introduce greater loss in this circuit. Hence the amount of control tone passing through the varistor 607 is a function of the amplitude of the speech currents entering the transformer 600.

Generally speaking, a device of this nature is employed so that the total load on the radio transmitter 202 remains practically the same, that is, the transmission of voice currents and control tone should approximately add up to the same algebraic sum at all times. The effect at the receiving end is that the combined output of the detector 227 is practically uniform whether it comes from the control tone source alone or from the combined control tone and speech current provided in the manner hereinbefore described.

That part of the circuit between and including radio transmitter 202 and radio receiver 205 is spoken of as a mutable link since it comprises a signaling channel capable of or liable to change from internal or external cause which may give rise to interfering energy or more specifically, subject to noise, fading or change of attenuation. It is to be understood, however, that the present showing is by way of example and that the term "mutable link" does not necessarily mean that a space radio link is necessarily involved but that the term is broader in its meaning and includes any channel liable to change from internal or external cause.

The volume controller 236 is a device generally under the supervision of a technical operator for controlling the volume as indicated by a monitoring device, not shown, connected between this unit and the receiving repeater 237. The receiving repeater 237 is like the other repeaters 216, 223 and 224, a one-way amplifying device.

The syllabic amplifier-detector 213 is a device which will be unoperated by the maximum noise which may be expected on the transmitting circuit but will be operated quickly by speech signals of both high and low amplitudes. It is connected to the hybrid coil 212 and delivers its output to the receiving chain 214.

The transmitting chain 214 has control over a number of pieces of apparatus. For instance, the lines leaving the transmitting relay chain 214 and ending in arrow-heads before the transmitting suppressors 217 and 219 indicate control over these suppressors by the transmitting chain. Likewise, the transmitting chain has control over the privacy circuit unit 218. Another line extending from the transmitting relay chain 214 passes through the armature and back contact of relay 104 in the telegraph transmitting apparatus and ends in an arrow-head at the control tone enabler 241, indicating that the transmitting relay chain controls said control tone enabler at all times when the relay 104 is in its normal position. As will be explained hereinafter, relay 104 operates at a particular time in order to delay the control of the control tone enabler by the transmitting relay chain. An-

other control from the transmitting relay chain 214 passes through the back contact and armature of relay 100, the resistance 101 and the windings of relays 102 and 103 to battery. When the transmitting relay chain operates this latter circuit is closed and disables the telegraph transmitting apparatus.

In like manner the receiving relay chain 228 controls the first receiving suppressor 231, the second receiving suppressor 233 and variable suppressor 234. Another control extends from the receiving relay chain 228 to the syllabic amplifier-detector 213 and will disable this amplifier-detector when the said receiving relay chain 228 is operated. A further control extends to the vogad 211 which acts for the purpose of maintaining the gain of this device at the point last set.

A relay 274 is indicated as being one of the relays of the receiving chain. This relay controls a normal open circuit extending to conductors 402 and 403 in the telegrad. The purpose of this will be explained more fully hereinafter.

The transmitting telegraph apparatus consists, generally, of a pair of tape transmitters 105 and 106. Each of these transmitters has a series of five contacts operating between a spacing battery lead 107 and a marking battery lead 108 and affecting, in turn, the segments 111 to 120, inclusive, of the multiplex distributor. This latter piece of apparatus consists, in general, of a motor and synchronizing equipment 110 operating a shaft 109. This shaft has upon it a number of brushes 121, 122, 123 and 124. The brush 121 as it passes successively over the segments 111 to 120, inclusive, connects these segments to the ring 125 which is connected through either the armature and back contact of relay 126 or the armature and back contact of relay 127, thence through the back contact and armature of relay 103 and the winding of the telegraph transmitting line relay 128 to a point on a potentiometer consisting of the resistances 129 and 130 whereby the relay 128 will respond to either marking or spacing potential and thus operate its armature accordingly. When relay 128 is operated by a spacing signal it closes a circuit through its armature and contact to render the telegraph tone enabler 131 ineffective to transmit telegraph tone from the source 132 to the hybrid coil 221. When the relay 128 is operated by a marking signal it opens this circuit which affects the telegraph tone enabler 131 in such a way that alternating current from the source 132 freely passes to the hybrid coil 221 and thence out over the radio transmitter 202.

It should be noted that when the transmitting chain 214 is operated and, consequently, relay 103 is operated, that a connection is extended from spacing battery lead 107 through the front contact and armature of relay 103 to the winding of relay 128 to hold this relay spacing and, therefore, continuously to block the transmission of telegraph tone from the source 132 to the hybrid coil 221.

The function of brush 122 is as follows: If the transmitting chain operates at any time before brush 122 comes in contact with segment 133 or segment 134, then relays 102 and 103 will be properly operated and further transmission of telegraph signals interrupted and the stepping of the tape magnet prevented. If, however, the operation of the transmitting chain 214 occurs while brush 122 is on either of these segments

133 or 134, a connection will be extended from battery, ring 135 over brush 122 to segment 133 and thence through the windings of relays 104 and 100, and the back contact and armature of relay 102 to ground. This causes the circuit for the operation of relays 102 and 103 to be opened to prevent the disabling of the telegraph apparatus for this very short interval. This arrangement is provided so that if the voice takes command of the circuit at or during the transmission of the last pulse of a telegraph code, this last pulse may be allowed to be transmitted without interruption, and the operation of the tape stepping magnet insured.

The function of brush 123 is as follows: The segments and rings of this multiplex distributor are developed for the sake of clarity and the brush 123, now moving downwardly, has reached the point where transmission of the signals from the tape transmitter 106 has been completed. Brush 123 now establishes a connection from ground, ring 136, brush 123, segment 137, back contact and outer right-hand armature of relay 138, winding of stepping magnet 139, right-hand contact and armature of relay 140 to battery. If relay 140 is on its right-hand contact, as it should be while this apparatus is operating normally, and there is a sufficient supply of tape for use by the transmitter 106, then the magnet 139 will operate and advance the tape to the next punched character. As brush 123 advances it next comes into contact with segment 141 where a connection is established from ground, ring 135, brush 123, segment 141, the contacts of the taut tape switch 142, which will be closed as long as there is sufficient tape in this transmitter, to the left-hand winding of relay 138. This connection also extends in parallel through the normal contacts and the inner right-hand armature of relay 138 through the right-hand winding of this relay, and these windings being opposed no operation of the relay 138 will occur. If, however, upon the operation of magnet 139 the taut tape switch 142 had operated, then only the right-hand winding of relay 138 would have been energized and this relay would then have operated and locked through its inner right-hand armature to ground. This condition would have persisted until the taut tape switch 142 closed its contacts again and brush 123 made contact with segment 141 whereupon the relay 138 would have been automatically released.

During the time that relay 138 is operated each of the segments 116 to 120, inclusive, would have been connected through the front contacts and left-hand armatures of relay 138 to marking battery, so that a signal consisting of five marking pulses would have been repeatedly sent each time the brush 125 passed over the segments 116 to 120, inclusive.

When brush 123 advances to segment 143 a connection is momentarily established from ground, ring 136, brush 123, segment 143, the lower winding of relay 140 to battery. This tends to drive relay 140 to its right-hand contact where it will remain unless some other circuit is closed to change this condition.

As brush 123 advances further it first causes the operation of stepping magnet 144 in a similar manner to the operation of stepping magnet 139 and attempts to operate the relay 145 and finally closes a circuit to drive relay 146 to its right-hand armature.

The function of brush 124 is as follows: If during the time that brush 124 is on segment 147, 75

relay 102 becomes operated, then a circuit will be established from ground, the armature and front contact of relay 102, ring 148, brush 124, segment 147, the upper winding of relay 146 to battery. Relay 146 will thereupon be driven to its left-hand contact where it will remain until brush 123 drives it back to its right-hand contact. During the time that relay 146 is on its left-hand contact it will cause the operation of relay 126 in an obvious circuit and thereby open the transmitting circuit which operates the telegraph transmitting relay 128. When brush 124 reaches the lower segment 149, it will cause the relay 140 to move to its left-hand contact whereupon the relay 127 will be operated and complete the opening of the circuit for relay 128. It will be noted that each of these relays 146 and 140 will be periodically returned to its right-hand contact at the ending of the period of activity of the other circuit, but if the telegraph transmitting apparatus is now rendered ineffective, the relay will return to its left-hand contact immediately thereafter and before any signals can be effectively transmitted.

It should be noted before leaving the description of the transmitting telegraph apparatus that if both the taut tape switches open the left-hand windings of relays 138 and 145, respectively, that the contacts and the left-hand armatures of relay 145 are connected to spacing battery so that first a series of five marking impulses and later a series of five spacing impulses will be transmitted. This provides for an occasional transition between a spacing and a marking impulse for the purpose of correcting the distributor speed at the distant end.

When the receiving chain 228 is in its normal unoperated condition then the telegrad will be enabled. This will render the telegrad effective to operate the receiving telegraph apparatus. At this time telegraph signals being received by the radio receiver are passed into hybrid coil 229 and thence into the band-pass filter 301 (which is essentially a part of the circuit generally termed telegrad) from which they are delivered to the telegrad. This results in the operation of relays 302, 303 and 304 to their marking contacts for each marking impulse delivered to the telegrad.

The device known as the telegrad is shown mostly on Fig. 4 and partly on Fig. 3. The telegraph signals leaving the hybrid coil 229 enter the band-pass filter 301 and pass through the circuit of the telegrad eventually appearing as direct current signals entering the upper windings of relays 302, 303 and 304 in series. Each marking signal will operate these three relays to their left-hand contacts and each spacing signal will operate these three relays to their right-hand contacts.

Signals coming from the band-pass filter 301 pass through a vario-repeater consisting of two stages, first, a copper oxide vario-losser pad and secondly, a push-pull variable- μ amplifier stage. The signals pass through a transformer 401 and thence through a cross-coil controller comprising a circuit including the windings of transformer 400 and transformer 401. When the pair of wires 402 and 403 leading to the armature and contact of the telegrad disabled relay 274 are connected together by this relay no signals will pass from the band-pass filter 301 into the further stages of the telegrad. In other words, the signals will be blocked by connection of conductor 402 to conductor 403. When the receiving chain

228 is released and relay 274 returns to its normal condition, the connection between conductors 402 and 403 will be opened and signals will pass freely into the circuit beyond transformer 401.

At this time the signals pass through the copper oxide vario-losser pad to transformer 404. From transformer 404 they pass in push-pull relation through two variable-mu suppressor pentode tubes 405 and 406 to another transformer 407. The copper oxide vario-losser pad comprises four copper oxide rectifiers 408, 409, 410 and 411 connected in a bridge circuit across the outer terminals of transformers 412 and 404 with a pure resistance 413 bridged thereacross. The outer apex points of this bridge are connected in one case to a potentiometer 414 between plus battery and ground and in the other case to the mid-point of the primary winding of transformer 407. The current flowing in the copper oxide bridge is then a function of the plate currents flowing in tubes 405 and 406 since the plate current drop across resistance 415 is balanced against the potential derived from the potentiometer 414. The larger the plate current flowing through resistance 415 the smaller will be the direct current flowing through the copper oxide bridge.

The important element in this vario-repeater is a condenser 416. The potential of the upper plate of this condenser determines the gain to the signal. The gain of the vario-repeater is increased by the raising of the positive charge on condenser 416 and is reduced by a corresponding reverse action adjustment. Through the use of a potentiometer 417 the potential of the upper plate of condenser 416 may be kept at such a point during idle periods that the vario-repeater is set at mid-gain.

The signals going out from transformer 407 pass through a suppressor grid pentode tube 418 and thence to a hybrid coil comprising the circuit connected between transformer 419 and transformer 420. The output of this hybrid coil works into a suppressor grid pentode tube 421, acting as an amplifier, to a transformer 422 and thence to a full wave rectifier tube 423. Under normal conditions, that is, in the condition of a spacing signal, a suppressor grid pentode tube 424 is so adjusted by the potential of the mid-point of the secondary of transformer 422 that current flows from the plate of tube 424 through a neutral relay 350 and the lower winding of relay 351 holding them in the positions shown.

When a marking signal is transmitted then a direct current voltage is produced across the diode resistance 425 and the negative voltage reduces the plate current from tube 424 to a point where relay 350 releases and the biasing current in the upper winding of relay 351 drives this relay to its marking contact. When relay 351 moves from its spacing contact, a short circuit on the hang-over condenser 355 is removed and this condenser in time is charged by the positive battery connected through the lower winding of relay 352. This charging current holds relay 352 on its spacing contact for the hang-over period. Thereafter as the biasing current through the upper winding of relay 352 becomes effective and relay 352 moves to its marking contact, a circuit is closed from ground through the armature of relay 351 and its marking contact, thence through the armature of relay 352 and its marking contact to the receiving relays 302, 303 and 304.

Since the telegrad is used at the output of a

selective filter 301, the length of the pulses reaching the input is longer than the signal transmitted. Since relay 351 follows the signals at the input of the telegrad, the circuit including relay 351 and the hang-over condenser 355 is provided to regulate the length of the pulses going out to the receiving relays 302 to 304, inclusive, to the length of the pulses before they pass through the band-pass filter 301.

In general terms, then, alternating current impulses which may vary from strong signals to very weak signals over a range of some 45 decibels are converted by the vario-repeater into alternating current signals of a practically uniform amplitude. These signals then pass through an amplifier-detector and appear at the output of the tube 424 as direct current signals and later in the upper windings of relays 302 to 304, inclusive, as direct current signals of uniform strength and of a length equal to the signals delivered to the band-pass filter 301.

It was pointed out above that the potential of the condenser 416 is normally adjusted by the potentiometer 417 to a point where the vario-repeater is set at mid-gain. If a very weak signal is received a gain increaser circuit operates to bring up the gain of the vario-repeater in a very short time. This time, for example, may be a minor fraction of a signal length. For a further specific example, this period may be of the order of 5 to 6 milliseconds, so that where the signal length is of the order of 22 milliseconds the time taken to change the gain of the vario-repeater becomes a minor fraction of the signal length.

The signaling current then passes into a transformer 426 through an amplifier comprising essentially a suppressor grid pentode tube 427 to a variable loss device comprising the circuit between the transformers 428 and 429. When relay 350 is in the position shown, the variable loss device 430 is in such condition that the alternating current signal will manifest itself in transformer 431 and thus place an alternating current potential at the terminal of the cold cathode gas-filled tube 432. This breaks down the gas tube and current flow therethrough is started, current flowing from a point on potentiometer 433 connected to plus battery through the tube 432, resistance 434 to ground. The drop across resistance 434 causes a second cold cathode gas-filled tube 435 to break down and thus apply positive potential to the condenser 416. Since the impedance of this condenser charging circuit is very low the condenser 416 is charged rapidly and the gain is changed, for example, in the order of 20 decibels in approximately 5 milliseconds.

When the gain has been brought up to the point where a direct current signal is produced by the tube 434, manifesting itself through the release of relay 350 and the movement of relay 351 from its spacing to its marking contact, this gain increasing circuit is disabled.

The disabling is done in two steps; first, the armature of relay 350 moves from its front contact and thus opens the circuit of the variable loss device 430 so that this circuit now becomes opaque to alternating current and the alternating current ceases to flow in the transformer 431. Thus the circuit for activating the tube 432 is disabled. Secondly, and shortly thereafter when the armature of relay 350 reaches its back contact, a ground is placed on the lower side of the secondary winding of transformer 431 or, in other

words, on the potentiometer point supplying positive potential to the tube 432 so that the enabling voltage normally applied to this cold cathode tube is reduced to ground potential.

Heretofore the gain increase disabler of circuits, known as vogads, have been operated directly by relay contacts. An analogy would be the charging circuit for condenser 416 passing through the contacts of relay 350. The transient voltage of this circuit, however, on opening the charging circuit is so high that the relay contacts cannot be used alone, and hence the gain increaser is disabled in the two-step manner just described, consisting of first disabling the activating circuit, and second in disabling the operating circuit of the gain increaser.

In order to keep the potential of the control condenser 416 from going too high when the gain increaser operates, the condenser 416 is shunted by a rectifier 438. This limits the voltage of the condenser 416 to a predetermined maximum value.

Two leads coming from the lower part of the hybrid coil comprising the circuit between the transformers 419 and 420 lead to a transformer 436 to apply voltage to the control gap of a gas tube 437. This breaks down the tube and causes the control condenser 416 to be charged negatively. This circuit constitutes a fast-operate backward-acting gain decreaser. This circuit, for example, will reduce the gain by 20 decibels in a period of 4 milliseconds.

Generally the action of the telegrad is as follows. When a weak signal is received, the gain increaser circuit causes the cold cathode tubes 432 and 435 to close the circuit for the charging of condenser 416 from a source of positive potential which acts to rectify the alternating current of the signal transmitted through the tube 427.

As the level of the signal at the transformer 420 reaches a predetermined point, relay 350 will be released and the gain decreaser circuit will come into operation. Due to certain electrical delays and the mechanical delay in the armature travel time of relay 350 to gain increaser is not disabled until the gain has gone slightly above the desired point. The gain decreaser then adjusts the signal with the result that a characteristically enlarged head is given to the intermediate stage signal, that is, the signal as it passes into the transformer 420.

When a strong signal is received the gain decreaser and the gain increase disabler relay operate at once subject to the inherent electrical and mechanical delays in the circuit and the gain increaser is disabled almost immediately again with the result that the intermediate stage signal appears to have a characteristically enlarged head.

By increasing the speed of the charging circuits of the condenser 416 the enlarged head will be made more prominent and by decreasing such speed the enlarged head may be reduced to a minimum.

When the gain decreaser has brought the potential of condenser 416 down to the proper level, tube 437 will cease to function and the charge on condenser 416 will remain constant thereafter except for the slow drift to mid-gain through potentiometer 417.

This is shown in Figs. 7 and 8, Fig. 7 representing a strong signal and Fig. 8 representing a weak signal. These figures have been drawn from oscillograms derived from actual experience and represent the transmission of the letter Y in

a well-known code. In each case there is a marking signal in the first, third and fifth places and a spacing signal in the second and fourth places. The upper line in each case represents the signal as it enters the band-pass filter 301, the middle line represents the intermediate stage signal as it enters the amplifier-detector through the transformer 420 and the lower line represents the signal passing through the upper windings of relays 302 to 304, inclusive.

It will be noted that the direct current signals are displaced in time in relation to the alternating current signals from which they were derived. Thus, in Fig. 7, the vertical line 700 represents in time the starting of an alternating current signal shown in the upper line. The vertical line 701 shows the corresponding starting time of the direct current signal. The length of time between the vertical lines 700 and 701 is practically uniform without regard to the strength of the signal. Thus, in Fig. 8 the vertical line 800, for instance, marks the beginning of an alternating current signal shown in the upper line and the vertical line 801 represents the starting time of the corresponding direct current signal. It will be noted that the distance between the lines 700 and 701 is practically equal to the distance between the lines 800 and 801.

In accordance with the present invention then the condenser 349 is provided and its value so adjusted that after the original energizing circuit for relay 339 is opened, this relay will not release for a time closely approximating the time between the lines 700 and 701 or 800 and 801.

Relay 302 is known as the receiving telegraph line relay and for each marking impulse it establishes a ground connection to the ring 305. Relay 304 is known as the corrector relay. Upon each spacing impulse this relay will cause its condenser 306 to be energized and upon each marking impulse this relay will deliver the condenser discharge into ring 307. Relay 303 is known as the auxiliary relay and operates on each marking impulse to drive either relay 308 or relay 309 to its left-hand contact, respectively.

The receiving telegraph apparatus consists, generally, of two printers 310 and 311 and a multiplex distributor comprising a motor and certain synchronous equipment 312 operating a shaft 313 carrying brushes 314, 315, 316 and 317.

As brush 314 moves downwardly it connects the ring 305 through segments 318, 319, 320, 321 and 322 to the selecting magnets of printer 311 and thereafter through segments 323, 324, 325, 326 and 327 to the selecting magnets of printer 310. Thus, for each marking impulse, one of the selecting magnets of printer 311 or printer 310 is operated.

Brush 316 in moving downwardly makes contact with segments 328 and then 329 while brush 314 is traversing the connections to the selecting magnets of printer 311. The segments 328 and 329 are associated with printer 310. The connection to segment 328 establishes a circuit from ground, ring 330, brush 316, segment 328, armature and contact of relay 308 to the printing magnet 331. Thus the selection set up on printer 310 is rendered effective by the printing magnet 331 after the brush 314 has completely traversed the segments 323 to 327 and is now engaged in passing over the segments 318 to 322. As the brush 316 advances it makes a connection from ground to segment 329, which leads to the lower right-hand set of contacts of key 332, for purposes which will be hereinafter described.

As brush 316 next traverses segment 333 the printing magnet 334 will be operated.

Brush 317 makes contact from the ring 335 to the segment 336 during the time that the brush 314 is traversing the segments associated with the printer 311. This circuit from ring 335 extends a battery connection to the two windings of the relay 309 through the rectifiers 337 and 338. If this telegraph receiving apparatus is now properly in operative condition there will be an open connection to the upper winding of this relay at the armature and contact of relay 339. Any marking impulse coming in at this time will be rendered effective by the auxiliary relay 303 to keep relay 309 on its left-hand contact and thus render the printing magnet effective. If, on the other hand, the receiving chain 228 is operated by voice currents, then relay 339 will be released and ground on the armature of relay 339 will cause relay 309 to be driven to its other position where the circuit for printing magnet 334 is opened. Similar action of relay 308 will take place when the brush 317 traverses the segment 341.

It will also be noted that when the relay 339 is operated, as when the receiving chain 228 is in its normal position, thus denoting the fact that the receiving telegraph apparatus is effective, that relay 340 will be operated. Relay 340 plays a particular role with relation to the key 332.

If the distant transmitter corresponding to transmitter 106 operates its taut tape switch so as to send out a series of five marking impulses, then the receipt of these five marking impulses by the printer 310 results in a thumping of the printer without the production of any printing. If this becomes annoying to the operator then the key 332 may be moved to its right-hand position. Thereupon a circuit will be established from battery, the upper right-hand contacts of key 322, the winding of relay 342, the lower right-hand contacts of key 332 to the segment 329 and when brush 316 makes contact with segment 329 a connection is extended to ground on ring 330. This causes relay 342 to operate and this relay locks up to battery on its inner right-hand armature. Relay 342 is sufficiently slow in releasing so that it will remain locked up in a manner now to be described. Upon the first operation of relay 342 a circuit for the operation of relay 343 is closed at the front contact and outer right-hand armature of relay 342. This relay now disconnects the segments 323 to 327, inclusive, from the selecting magnets of the printer 310 and extends them to conductor 344 which, with the left-hand contacts of key 332 in their normal position, extends the ground connection each time the brush 314 connects with a segment 323 to 327, inclusive, to the winding of relay 342 to maintain this relay operated.

If at the distant end the taut tape switch should return to normal then ground impulses will not be supplied to the winding of relay 342 at sufficient intervals to keep this relay operated and it will therefore release and by releasing cause relay 343 to return to normal, so that the printer 310 again becomes effective. If during the time that relay 342 is locked up the receiving telegraph apparatus is rendered ineffective by the operation of the receiving chain 228, then relay 340 returns to normal and this maintains relay 342 locked up until the telegraph apparatus is again rendered effective through the operation of the receiving chain 228.

The relay 342 may be unlocked at any time by moving the key 332 to its left-hand position.

As brush 315 moves it alternately makes contact with segments connected to either conductor 345 or 346. These conductors are connected to different windings of the corrector relay 347 and therefore the discharge of the condenser 306 will tend to operate the relay 347 in one direction if the motor 312 is running fast or operate the relay 347 in the other direction if the motor 312 is running slow. The correcting means is well known and will not be further described except to note that a device 348, which will indicate fast or slow operation, is inserted at this point to indicate that correction may be properly made.

Attention is particularly called to the condenser 349 connected in parallel with the receiving check relay 339. When the voice takes command and the receiving relay chain 228 is operated the circuit of relay 339 is opened and relay 339 releases to drive relay 308 or relay 309, as the case may be, to its right-hand position thus opening the circuit for the printing magnet 331 or the printing magnet 334. Since at the time that the receiving relay chain is operated the telegraph may not have completed the setting of the selecting magnets in printer 310 or printer 311. The operation of the relay 308 or the relay 309 would be premature if condenser 349 were not provided. When the circuit of relay 339 is opened, therefore, relay 339 will not immediately release since condenser 349 must be charged through the winding of relay 339. Thus the addition of condenser 349 provides a hang-over operation of relay 339 and this may be adjusted by the proper selection of the value of the circuit constants to equal the delay caused in the transition of a signaling impulse through the telegraph.

If relay 339 is released too soon and the character set up on the selecting magnets is therefore not completed by a printing operation, the mutilation which would result, would consist of the loss of two correctly printed characters and the substitution therefore of one incorrectly printed character. Such mutilation is particularly liable to occur where the telegraph transmission is interrupted near the end of the transmission of a character code or in other words when the voice at the transmitting end takes command of the channel while brush 122 is about to, or has made, contact with segment 133, for such contact insures the stepping of the tape printer and hence the corresponding action of the printing magnet 334 must also be insured.

By way of example, if the word SENT were being transmitted and the speech takes command at such a time that the transmission of the code for the letter E has been insured but due to the lack of the hang-over operation provided by the condenser 349 the printing operation is prevented by the premature opening of the circuit magnet 334. Then when the operation of the telegraph apparatus is resumed the code for the letter N will be superimposed on the code for the letter E already recorded on the selecting magnets. The code for the letter E is a single marking impulse in the first code space while the code for the letter N is two marking impulses in the third and fourth code spaces. The result will be marking registration in the first, third and fourth code spaces of the selecting magnets and since this represents the code for the letter F, the printing record will appear as SFT instead of SENT. Thus two correct characters are lost and are replaced by one incorrect character.

All mutilation, of course, will not be of this particular character as at times the registration of the second character may not mutilate the first or the registration of the second character may not be mutilated by the first, but a whole character will be lost. The addition of the condenser 349 prevents this type of mutilation.

The diagram in Fig. 9 is practically self-explanatory. It is an idealized timing chart of the terminal switching. Line 901 shows the telegraph signals, as manifested by the operation of relay 128, being interrupted in the middle of a signal. A dotted vertical line 900 represents the time at which speech shown in line 902 takes command of the circuit. The next line 903 represents the transmitting detector and hang-over time and hence the time during which the control tone is sent out from the source 240 is lengthened by an amount extending from the line 912 representing the ending of speech to the time represented by the line 913 representing the release of the control tone enabler 241. The line 904 represents the speech after it has passed through the delay circuits. The line 905 represents the control tone transmitted and illustrates graphically the action of the compressor shown in detail in Fig. 6. The line 906 represents the time during which the transmitting telegraph apparatus is disabled. It will be noted that this time extends somewhat from line 913 to the time represented by the vertical line 914 and this represents the hang-over period provided by the transmitting chain 214. Line 907 is a composite picture of the line signal showing first, telegraph tone signals and then, after the vertical line 900 is crossed, a small interval of control tone and thereafter a current representing speech and control tone being simultaneously transmitted. After the ending of speech and until the time represented by the vertical line 913 is reached, there is shown a period of transmission of control tone. Somewhat later and after the time represented by the vertical line 914 is passed another telegraph signal appears. The line 908 represents the received signal at the distant end. Here the line signal of line 907 is effected by fading and noise and hence has a considerably different appearance from that shown in the line 907 above. It will also be noted that this signal is displaced somewhat in time from the transmitted signal of line 907. In line 909 is shown the received telegraph signals after the telegrad has reshaped and retimed them and here the displacement in time is pronounced. Line 910 represents the receiving telegraph checking circuit as controlled by the relay 339. Here the checking circuit does not operate for a time represented by the difference between the vertical line 915 and the vertical line 916 which represents the hang-over provided by the condenser 349. Line 911 represents the received speech to the subscriber showing the action of the variable suppressor 234 in gradually opening and closing the speech path.

What is claimed is:

1. In a telegraph system, a transmission channel, means for transmitting telegraph signals in the form of alternating current over said channel, a telegrad for converting said signals into equal length direct current signals, said converted signals being displaced in time relation with respect to said alternating current signals, relay means for signaling the starting and stopping of telegraph transmission over said channel and a hangover circuit for said relay means for

displacing the time relation of said stopping signal to correspond with the displaced time relation of said telegraph signals in said telegrad.

2. In a communication system, a transmission channel, means for normally transmitting telegraph signals over said channel, voice controlled means at the transmitting end of said channel for stopping and starting the said transmission of telegraph signals over said channel, telegraph receiving apparatus at the receiving end of said channel including a telegraph for converting incoming telegraph signals into a different form, the telegraph signals outgoing from said telegrad being delayed in time relation with respect to the corresponding telegraph signals incoming to said telegrad, said telegraph receiving apparatus including relay means responsive to said voice controlled means for signaling to other telegraph apparatus beyond said telegrad the starting and stopping of the transmission of telegraph signals into said telegrad and means for delaying the stopping signals by said relay means for a period corresponding to the delay of said telegraph signals while passing through said telegrad.

3. In a communication system, a transmission channel, means for normally transmitting telegraph signals over said channel, voice controlled means for interpolating voice current transmission in said telegraph signal transmission over said channel, said voice controlled means including direct controlled switching means at the transmitting end and remote controlled switching means at the receiving end of said channel, means at the receiving end of said channel in the path of telegraph signals operating to delay the transmission of said signals therethrough, and means responsive to said remote controlled switching means for rendering telegraph receiving apparatus beyond said signal delaying means operative and inoperative, said last means being provided with hang-over means for delaying its said function of rendering said receiving apparatus inoperative for a period corresponding to the said delay in said telegraph signals.

4. In a communication system, a transmission channel, means for normally transmitting telegraph signals over said channel, means for alternatively transmitting voice currents over said channel, switching means for changing to and from said normal condition from and to said alternative condition, voice controlled means for operating said switching means at the transmitting end of said channel and for connecting a source of control tone to said channel, means at the receiving end of said channel responsive to control tone for operating said switching means thereat, a telegrad in the path of telegraph signals at the receiving end of said channel, the telegraph signals outgoing from said telegrad being delayed in time relation to the corresponding signals incoming to said telegrad, a relay included in said switching means at the receiving end of said channel for controlling telegraph apparatus operated by the output signals from said telegrad, and means for delaying the release of said relay for a period corresponding to the delay to which said telegrad subjects the telegraph signals passing therethrough.

5. In a communication system, a teletypewriter printer, a selecting means in said printer operated by permutation code signals, a circuit including a telegrad for delivering permutation code signals to said selecting means, a printing relay in said printer for causing a printing oper-

ation after said selecting means has been completely set by said code signals, said telegrad operating to displace the time relation between incoming and outgoing signals, a means for controlling said printing relay operated from a circuit associated with the incoming terminals of said telegrad, and means for delaying the disabling of said printing relay for a period corresponding to the delay to which said telegrad subjects the signals outgoing therefrom.

6. In a system in which impulses comprising individual elements of code combinations are received as groups of carrier waves the method of selectively converting the groups of carrier waves to rectified code impulses in a manner in which the code impulses are delayed in time with respect to the corresponding groups of carrier waves and delaying by an approximately equal amount the action of control pulses which are derived from received carrier waves.

7. In a system of reception in which control pulses and signal pulses are selectively derived from received carrier waves by apparatus which causes a displacement of the signal pulses with respect to their corresponding carrier waves, the method of restoring the time relation of the control pulses and signal pulses which comprises specially delaying the control pulses to restore the correct time relationship.

8. In a receiving system wherein code combinations are intermittently transmitted and received, a control signal for controlling the intermittent stopping of the code transmission, carrier wave means for conveying the code combinations and the control signal to a receiver whereat are means for translating the code combinations into intelligence, and means for translating the control signal into an electrocontrolling voltage to condition the means for translating the code combinations to a non-translating

condition, the means for translating the code combination into intelligence having a delaying characteristic, in combination with means for similarly characteristically delaying the conditioning to a non-translating condition of the means for translating the code combinations.

9. In a code controlled tele-receiving system, means for receiving a code carrying wave and a wave for suppressing tele-receiving, means operative incidental to the receiving of the code carrying wave for delaying the effect of component parts thereof, and means operative to correspondingly delay the effect of the wave for suppressing tele-receiving.

10. A receiving system comprising detecting instrumentalities for detecting coded groups of waves to produce coded groups of impulses, a device operated by the coded group of impulses to make a record in accordance therewith, means incidental to said production to produce a time delay, detecting instrumentalities operated by a control wave to condition said device to a non-recording condition, and special means to delay production of the non-recording condition by an amount equal to the time delay aforesaid whereby failure to record properly a last code impulse received prior to the reception of the control wave is prevented.

11. In a receiving system wherein means operative upon reception of a courier wave to inhibit telegraphic recording in preparation for speech reception, and wherein means operative upon cessation of reception of the courier wave prepare for telegraphic recording, means for making the inhibiting means slow acting and the preparatory means fast acting.

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