May 12, 1942. P. HOLCOMB, JR 2,282,358

TELEGRAPH SYSTEM

Filed Dec. 7, 1939 5 Sheets-Sheet 1

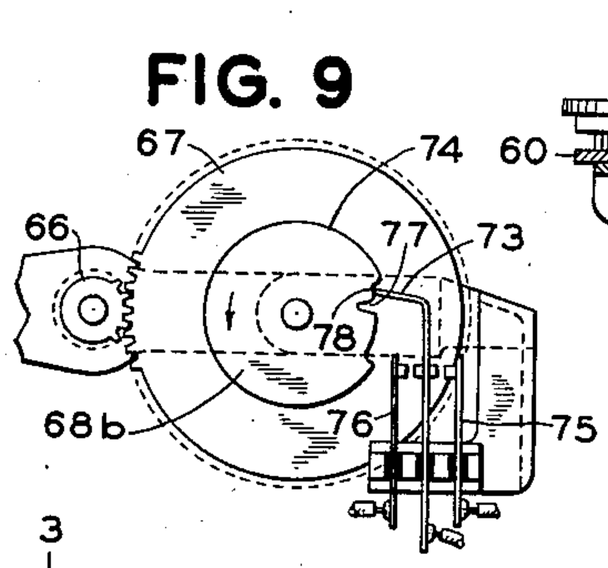

FIG. 9

FIG. 2

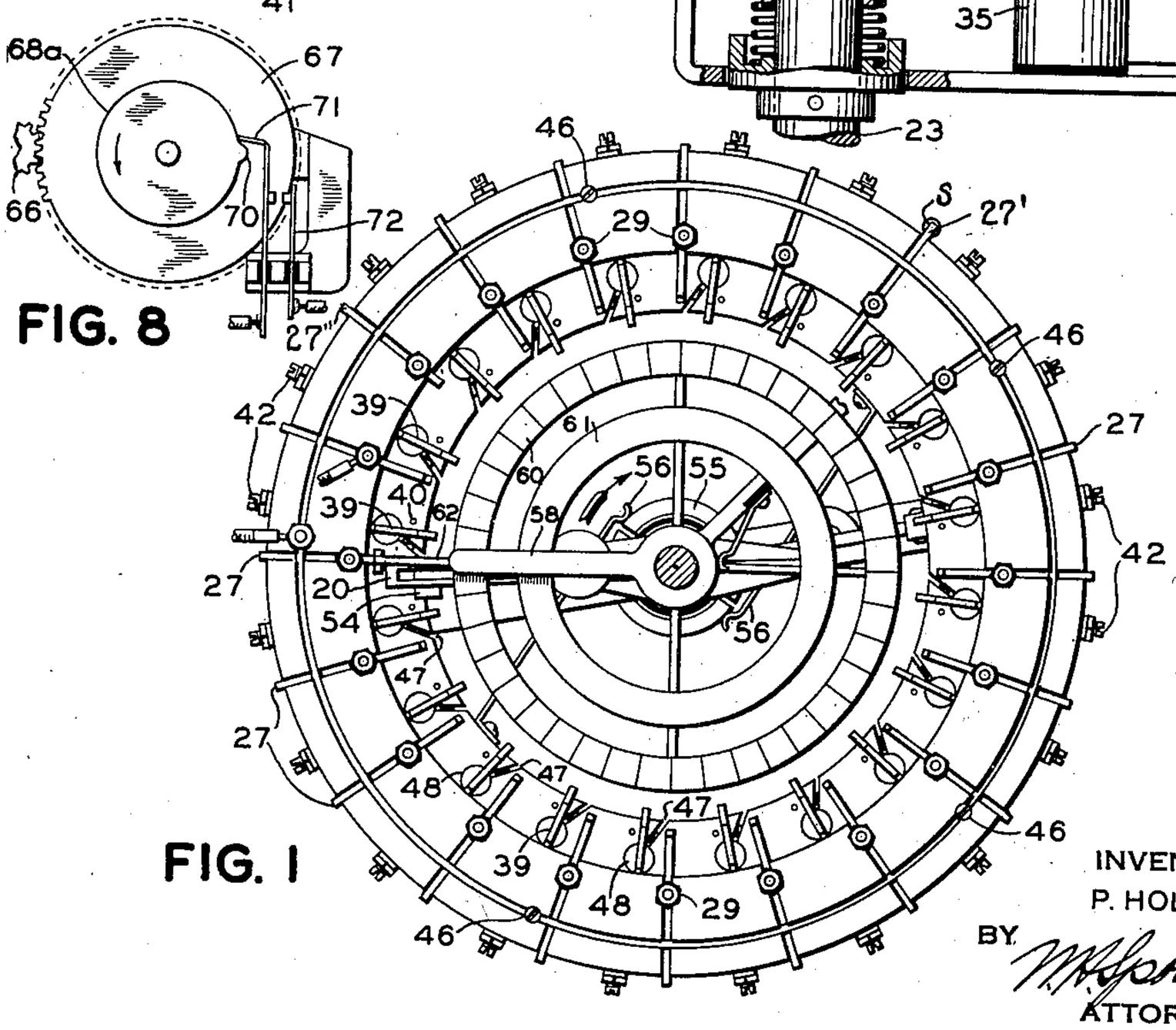

FIG. 8

FIG. 1

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FIG. 3

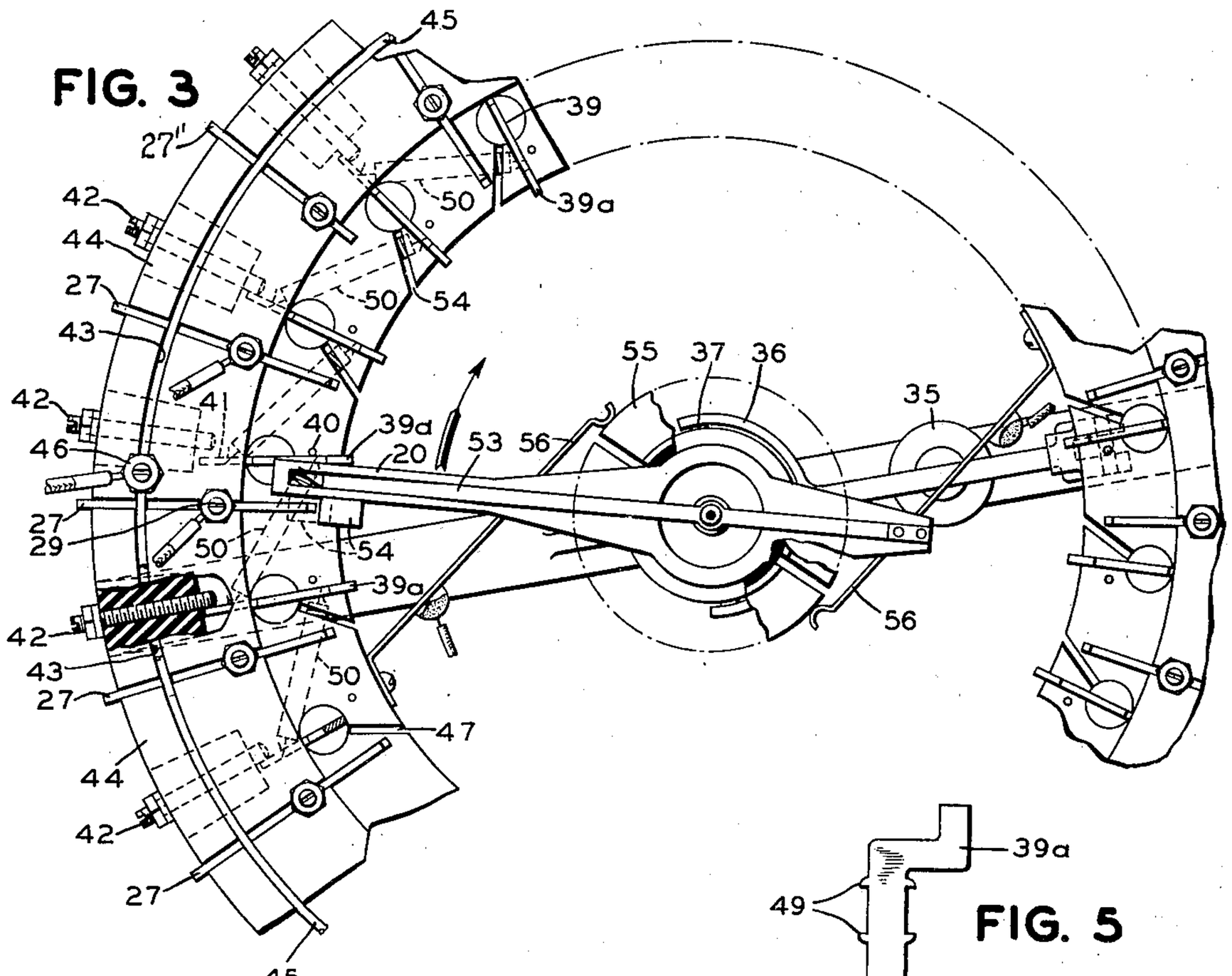


FIG. 5

FIG. 4

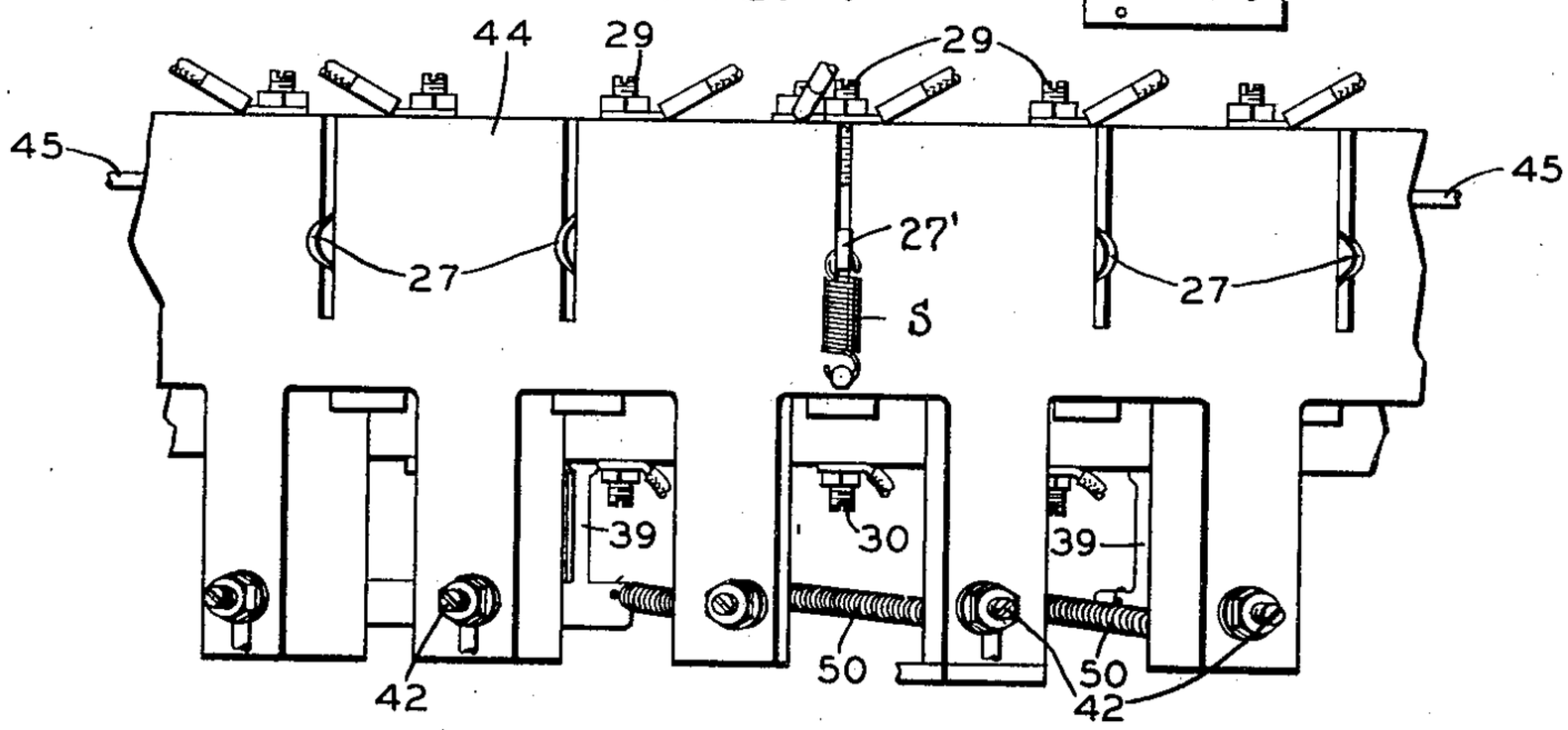


FIG. 7

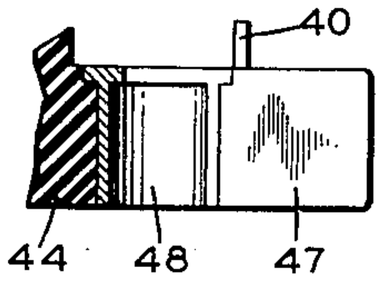
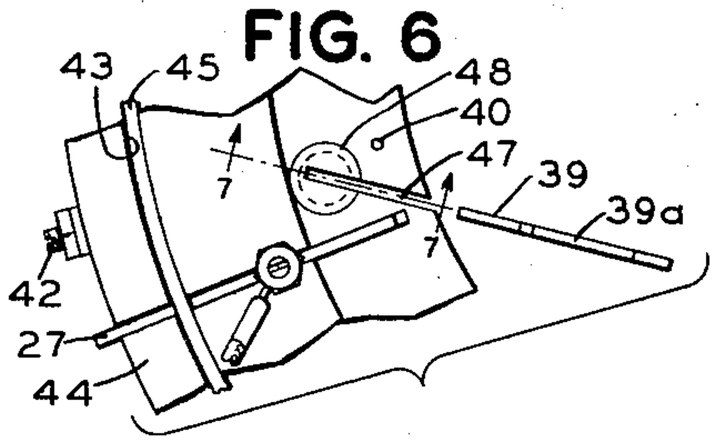


FIG. 6



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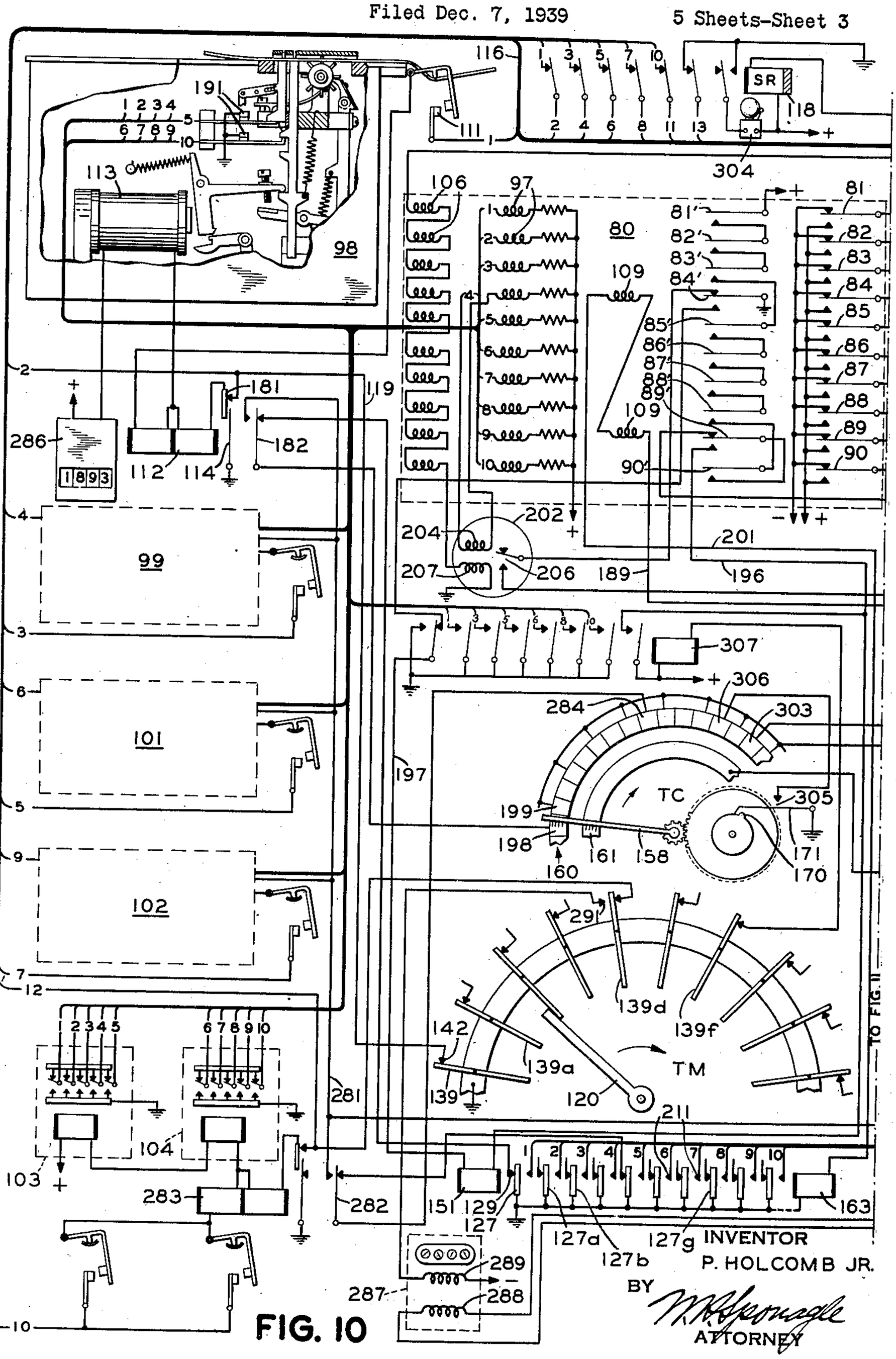

FIG. 10

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FIG. 11

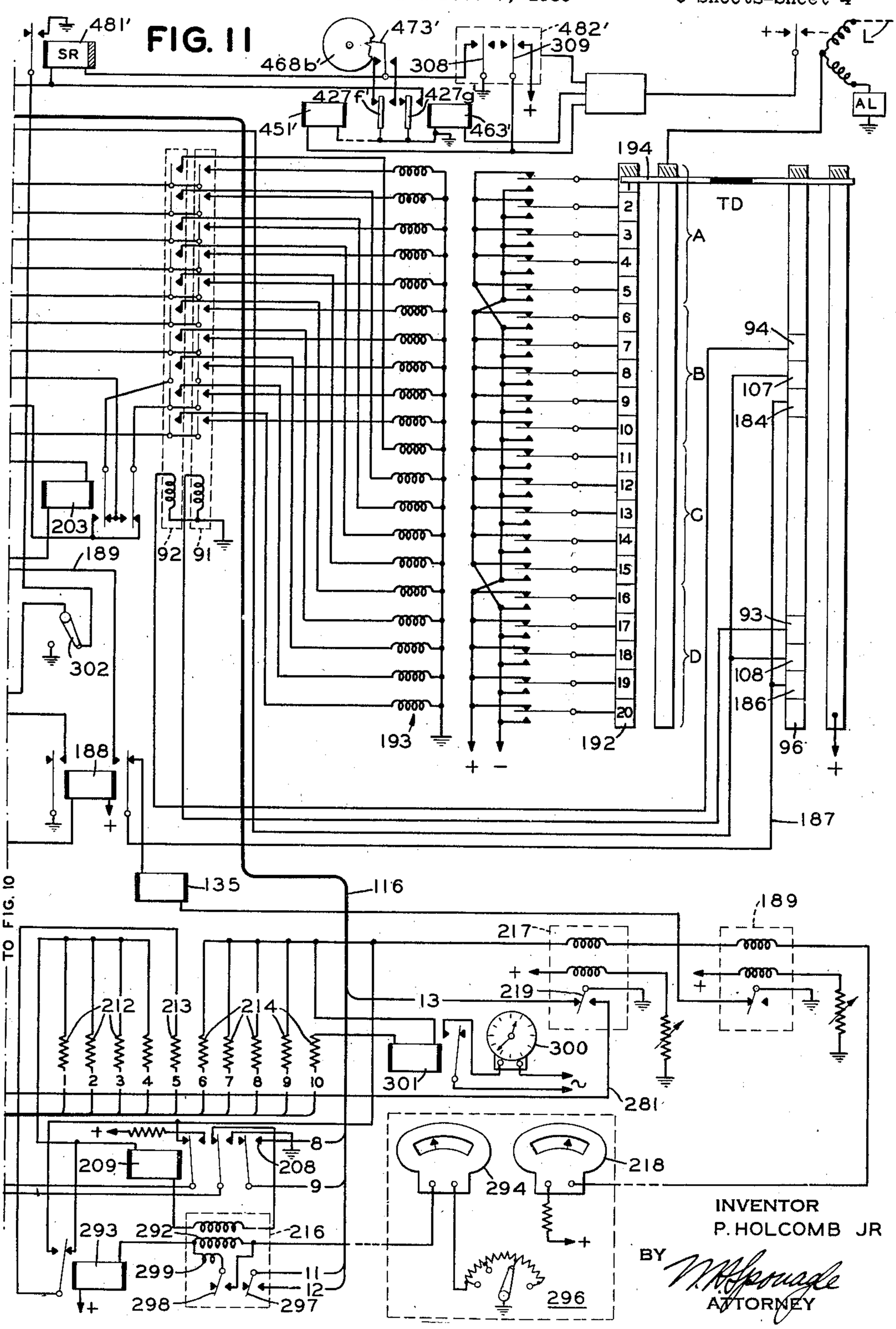

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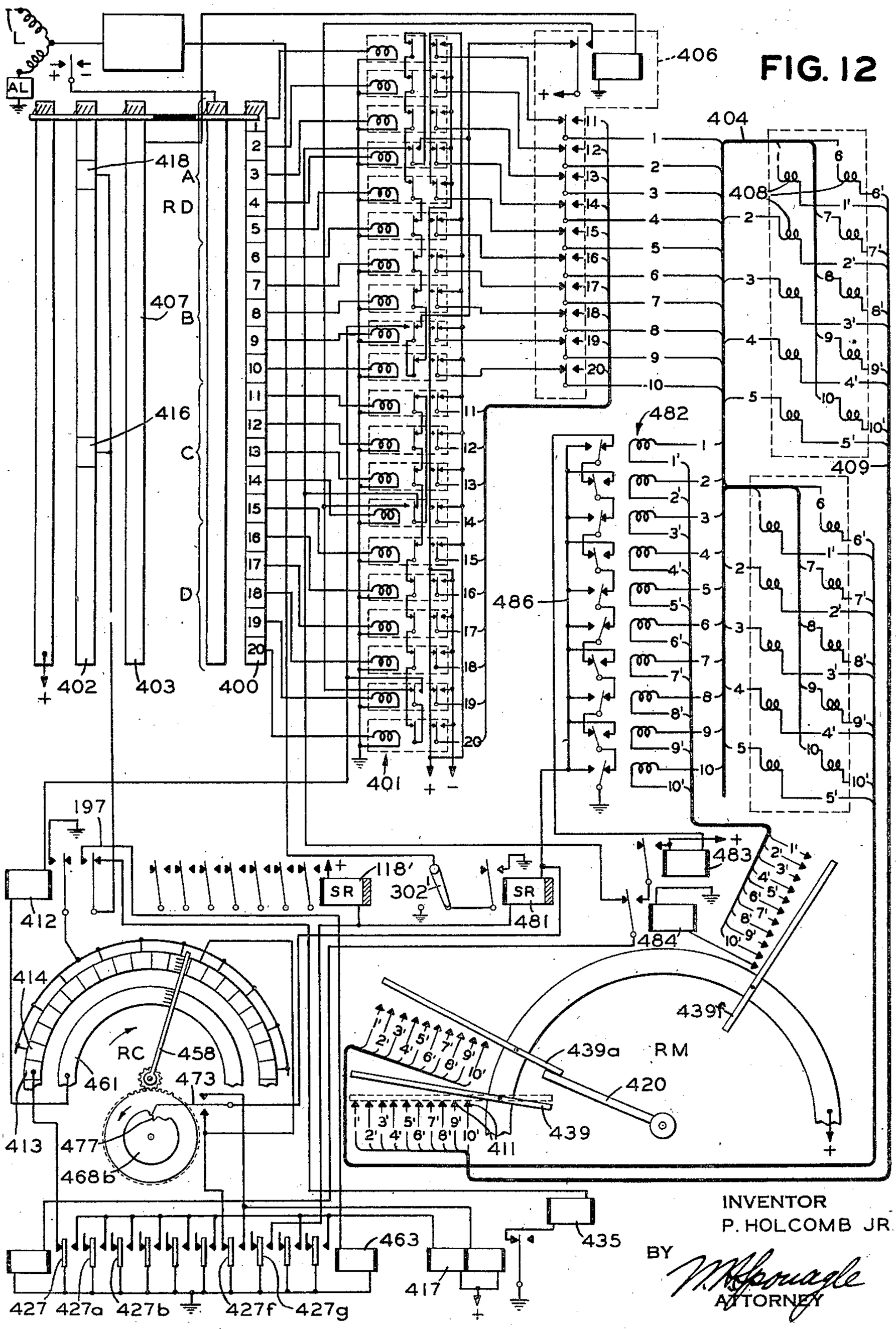
FIG. 12



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Patented May 12, 1942

2,282,358

UNITED STATES PATENT OFFICE

2,282,358

TELEGRAPH SYSTEM

Philo Holcomb, Jr., Great Neck, N. Y., assignor to The Western Union Telegraph Company, New York, N. Y., a corporation of New York

Application December 7, 1939, Serial No. 308,052

10 Claims. (Cl. 178—52)

This invention relates to signalling systems and more particularly to expanding channel or varioplex telegraph systems wherein a channel or lane of traffic is shared by a variable number of communication channels or sources of telegraph signals.

In a prior application Ser. No. 666,004, filed April 16, 1933, there is disclosed a telegraph system embodying the basic principle of the expanding channel system. The term "expanding channel system" as used herein refers to a system in which a variable number of telegraphic transmitters or other sending devices are arranged to control receiving devices corresponding to each sending device over a lane of traffic, substantially the entire lane time in the preferred system being divided among the operative transmitters. The lane of traffic preferably comprises a plurality of channels of a synchronous multiplex system but may comprise a single channel of such a system, one or more wire or carrier current channels or combinations of different types of communication channels. Hence the expression "lane of traffic" as used herein designates any suitable route or medium over which signalling is accomplished.

The expanding channel or varioplex system thus comprises a multiplex system in which the number of communication or subchannels operating over the connecting circuit or lane of traffic may be expanded or contracted by cutting in or out transmitting and receiving devices, the operative channels sharing the lane of traffic. The present invention relates particularly to a printing telegraph system of this character in which message characters are sent in sequence from one busy channel transmitter after another, omitting the idle or inoperative channels, although it is not limited to such systems.

The present invention is disclosed in a system which is related to the system disclosed in a prior application of Philo Holcomb, Jr., Ser. No. 123,266, filed January 30, 1937, in which the apparatus employed for controlling the signalling channels is in large part mechanical. However, it is not contemplated that the present invention be limited to such a system. A telegraph system of this character is particularly useful to serve a large number of signalling channels each of which has a comparatively small amount of traffic. In operation each of the sub-channels of an expanding channel system is in effect provided with a communication channel which is available for use at all times. The chief advantage of such a system is that the charges which are made to a subscriber having such a signalling channel may be based upon the actual use that such a subscriber makes of the signalling facilities. It is therefore possible to provide a subscriber with what in practice amounts to the equivalent of a private wire at rates which are materially less than the rates which would be charged for the exclusive use of a circuit between two distant points.

It is the practice to meter the traffic at the transmitting end of the circuit or, in other words, the point at which the traffic originates. Therefore, it is necessary to deliver at the receiving point all or substantially all of the traffic which is transmitted. In order to accomplish this purpose it is necessary that the system be so arranged that there is a minimum probability of the transmitted traffic being lost or mutilated in its transmission over the circuit.

Accordingly it is one of the objects of this invention to provide an expanding channel system which is so infallible in operation that equitable charges based on the number of message characters transmitted may be made to the subscribers of the various signalling channels.

Another object of the instant invention is to provide an expanding channel system in which periodic tests are made to insure the correct connection of corresponding transmitting and receiving apparatus.

Another object of the invention is to provide, in an expanding channel system, a means of testing the allocation of signalling channel apparatus which is operable over an auxiliary subchannel of the system.

Another object of the present invention is the provision of means for detecting incorrect allocation of channel equipment under certain conditions at times other than that of the periodic tests.

Another object of the invention is to provide means for metering the signalling channel traffic which is based upon the number of message characters transmitted, taking into account the simultaneous use of the lane of traffic by a variable number of other sub-channels. An advantage of such a metering arrangement is that the rate at which a subscriber is charged for service is in accordance with the simultaneous demands of other channels for transmitting time on the lane of traffic. It is obvious that at a time when the lane of traffic is in demand by a large number of channels, each unit of the transmitting time is more valuable than at a time when

a fewer number of channels require a share of the lane time.

It is another object of the instant invention to provide means for metering the signalling channel traffic on the basis of the number of characters transmitted and the frequency of transmission. With a large number of channels operating over the lane of traffic, the frequency of transmission from any one channel is less than it is when a smaller number of channels is operating. Hence the frequency of transmission from any signalling channel is a measure of the busy condition of the lane of traffic.

Another object of the invention is to provide a means of metering the traffic of a signalling channel on the basis of the total operative time of the channel.

Another object of the instant invention is to provide a means for controlling the entry of a signalling channel so that the maximum rates which will be charged for the transmission of the channel traffic may be fixed at a rate selected by the subscriber.

Another object of the invention is to make provision for giving a subscriber a means of controlling the maximum rates which he will be charged for the transmission of his traffic.

Another object of the invention is to provide means whereby a signalling channel may be entered only when the lane of traffic is being used by other sub-channels in numbers such that the rates are equal to a preselected rate and whereby a subscriber may have the advantage of any rate less than the preselected rate if the total number of signalling channels is reduced during his operative connection with the lane of traffic.

Other objects and advantages of the invention will become apparent from the following description of a system embodying the invention taken in conjunction with the accompanying drawings, of which:

Figs. 1 through 9 are views of one form of mixer or subchannel control device used in the system embodying the invention;

Figs. 10 and 11 illustrate diagrammatically the circuits and apparatus of the transmitting station; and

Fig. 12 is a diagrammatic representation of the circuits and apparatus of the receiving station.

A varioplex, or expanding channel, system comprises a plurality of channels which, when operative, are selectively associated with a common lane of traffic which, in the present embodiment, is constituted by a synchronous four-channel or quad multiplex. Such a system utilizes a selector or mixer by which the operative channels are successively connected to the lane in a prearranged order. The operative or inoperative condition of a channel is automatically registered at the mixer so that its operation is governed in accordance with said conditions to divide substantially the entire lane time among the operative channels.

The system comprising the present invention utilizes a mixer which is somewhat more mechanical in nature than those used in earlier varioplex systems. For each lane of traffic there is provided at the terminals a transmitting mixer and a receiving mixer. Figs. 1 through 9 illustrate the details of the transmitting mixer, the receiving mixer being substantially similar.

Referring to Figs. 1, 2 and 3 and, for the moment, particularly to Fig. 2, a mixer arm **20** forms part of, or is secured to, a hollow hub **21**, which is rotated through a friction clutch **22** by a continually rotating shaft **23**. The driven plate **24** of the clutch is characterized by a plurality of radial tongues **25** arranged in spaced relation peripherally of the plate and adapted to engage with vertical grooves **26** in the hub, whereby rotative motion may be transmitted to the hub, at the same time permitting axial movement thereof with respect to the driving shaft. Adjacent the extremity of the mixer arm **20** is a stop bar or latch member **27** pivoted at its upper lug **28** and having two operative positions, the one shown in full lines corresponding to a "channel in" condition and the one shown dotted corresponding to a "channel out" condition. The movements of the stop bar are limited by screws **29** and **30** to which electrical connections may be made. Maintenance of either stop bar position is obtained by the engagement of the lower lug **31** with a retaining member **32** which comprises a plunger **33** normally having the position shown, but which may be momentarily depressed against a spring by the lower lug as the stop bar is moved from one position to the other.

The stop bar **27**, when depressed in its "channel in" position is in the path of the rotating mixer arm and consequently engages and prevents further rotation thereof. With the mixer arm temporarily held by a stop bar corresponding to a channel which is to be given a portion of the lane time, the hub **21** is moved axially downward against the spiral compression spring **34**. This downward movement is effected by energizing the winding of the magnet **35** which attracts a pivoted fork **36** having pins **37** adapted to engage a circumferential channel **38** of the hub **21** and thereby transmit the motion of the fork to the hub and mixer arm **20**. The depression of the mixer arm to the position shown dotted releases it from the stop bar **27** and permits further rotation which results in the engagement of the arm **20** with a lever **39**. This lever is pivoted by the rotation of the mixer arm until a stop pin **40** is engaged, the pivoting being sufficient for the contact arm **41** to make or break (in this case break) a connection with a contact screw **42** and thereby connect the channel associated therewith to the lane of traffic as hereinafter described. Immediately thereafter the solenoid **35** is deenergized releasing the fork **36** and permitting the spring **34** to restore the mixer arm **20** to its upper position. It is thus disengaged from the lever **39** and continues its rotation until stopped by the next stop bar which is depressed in a "channel in" position.

One or more of the stop bars such as **27'**, best illustrated in Fig. 4, is provided with a spring S which normally urges the stop bar upward against its associated contact screw **29**. Such a stop bar may be selectively moved to its "channel in" position by a positioning means provided for this purpose in the same manner as any of the other stop bars, as described hereinafter. However, it is maintained in its "channel in" position, in engagement with its associated contact screw **30**, only as long as the positioning means remains operative. As soon as this means becomes inoperative, the stop bar **27'** is immediately returned to its "channel out" position by the spring S.

One or more of the stop bars such as **27''** may be shortened sufficiently to permit the unimpeded passage of the mixer arm **20** when the stop bar is in its "channel in" position. The length of such a bar is sufficient to permit its being moved from its "channel out" position to

its "channel in" position by the positioning means hereinafter described. However, it will become apparent that the apparatus disclosed herein is incapable of moving such a bar from its "channel in" position to its "channel out" position. It is contemplated that the restoration of a bar such as **27''** to its "channel out" position is to be effected manually.

The functions and modes of operation of stop bars such as **27'** and **27''** are described in subsequent portions of the specification.

A plurality of such sets of stop bars and operating levers are arranged peripherally around the plane of rotation of the mixer arm **20** as may be seen in Figs. 1 and 3, each set corresponding to a channel which may have access to the lane of traffic. A circular trench or groove **43** is formed in the stop surface of the insulating mounting **44** and imbedded therein is a wire or rod **45** (see Fig. 2) which is passed through the upper lugs of the stop arms and serves as the pivot therefor. This pivot rod also serves as a means of electrically interconnecting the stop arms and is held in the bottom of the groove by several screws, one of which **46** is arranged to termiate an electrical conductor.

Fig. 5 illustrates one of the channel operating levers **39***a* in a side elevation. Fig. 6 is a top view of the lever in position to be inserted into the mounting **44**. The lever is entered in a slot **47** and an aligning slot in a bushing **48** (shown sectionally in Fig. 7). The projections **49** formed on the lever (see Fig. 5) are arranged to engage the upper and lower flanges of the bushing, thereby preventing endwise movement of the lever. When the lever is fully within the bushing, it is given a counter-clockwise turn when viewed from the top, thus moving it out of alignment with the slot **47** and completing its positioning in the mounting. As illustrated in the partial side elevation of Fig. 4 and the plan view of Fig. 3, each operating lever **39** is normally held in contact with its associated contact screw **42** by means of a retractile spring **50** which is attached to the outer arm of one lever and to the inner arm of the lever succeeding it in the direction of rotation of the mixer arm **20**. The retractile springs may also serve as electrical connections between the various operating levers.

Facilities are provided for repositioning the stop bars of channels, the status of which changes during operation of the system. Assume that, in Fig. 2, the mixer arm **20** is engaged with the stop bar **27** which is associated with a channel to be disconnected from the lane. A solenoid **51** mounted within the upper portion of the hub **21** is energized and draws a plunger **52** downward. An arched leaf spring member **53**, having one end fastened to the mixer arm and the other end free and equipped with a cut-out lug **54** projecting from the trailing edge of the arm (see Figs. 1 or **3**), is flattened by the downward movement of the plunger **52**, thereby sliding the lug toward the outer end of the mixer arm into the position shown dotted in Fig. 3. The mixer arm is then escaped under the stop bar **27** to engage the operating lever **39**. When, subsequently, the mixer arm is released to its upper position, the lug **54** engages the lower edge of the stop bar and carries it upward to its "channel out" position before the mixer arm escapes from the operating lever **39**. External connections are made to the solenoid **51** by means of a two segment commutator **55** and a pair of brushes **56**.

The apparatus for depressing the stop bars into "channel in" positions is shown in Figs. 1 and 2. It comprises a supporting bracket **57** and a brush arm **58** both secured to a shaft **59** which is rotated in a definite timed relation with the multiplex distributor. The brush arm traverses a pair of rings, one segmented **60** and the other solid **61**, each channel being associated with two of the segments of the ring **60**. The bracket **57** serves as a support for a pivoted cut-in bar **62** and a solenoid **63** for the operation thereof. One terminal of the solenoid winding is grounded to the bracket **57** and the other connected to a slip ring **64** to which external connection may be made through a brush **65**. The above described mechanism is referred to hereinafter as a clock and rotates as stated hereinbefore entirely independent of the mixer arm. The brush arms of the transmitting clock and a similar receiving clock are geared to or otherwise controlled by the transmitting and receiving distributors of the synchronous multiplex system in order to effect the simultaneous entry of a transmitter at the sending station and a receiving device at the receiving station.

The entry of a channel is effected while the mixer arm **20** is engaged with the stop bar **27** of any operative channel and only at such time as the brush arm **58** is in engagement with the segments of ring **60** corresponding to the channel desiring entry. At this time the cut-in bar **62** will be directly over the stop bar **27** associated with this channel, so that the energization of the solenoid **63** actuates the cut-in bar to depress that particulr stop bar into its "channel in" position, thereby entering that channel into an operative relation with the line of traffic.

The mixer is also provided with apparatus having the function of periodically checking the subchannel arrangement at opposite ends of the lane of traffic. This apparatus comprises a gear **66** secured to the clock shaft **59** and arranged to drive another gear **67**. A cam **68** is secured concentrically to the gear **67** for the purpose of controlling the operation of a set of contacts **69**. The ratio of the gears is such that gear **67** makes one revolution for several revolutions of gear **66**. Fig. 8 is a fragmentary top view of the cam and contact arrangement for the transmitting mixer and shows the cam **68***a* provided with a small raised portion **70** which, when engaged with the movable contact member **71**, effects the latter's engagement with an auxiliary contact **72**. Fig. 9 is a similar view for the corresponding apparatus for the receiving mixer. While the movable contact **73** is bearing on the cam surface **74**, this contact is engaged with an auxiliary contact **75**. Contacts **73** and **76** are closed when the end of contact **73** drops into a notch **77** and when the contact **73** is bearing upon the cam surface **78**, it is disengaged from both of the auxiliary contacts.

The co-ordination of the various functions of the mixer and clock is more thoroughly described in succeeding paragraphs dealing with the operation of the system in more detail. The pertinent parts of the mixer and clock are represented schematically in the figures relating to the aforementioned description, but in order to facilitate their identification, they will be given reference numerals corresponding to those used in the description of Figs. 1 through 9, but having a prefix of **1** as illustrated in Figs. 10 and 11 and a prefix **4** as illustrated in Fig. 12.

Referring to Figs. 10, 11 and 12 of the drawings, there is illustrated an expanding channel

system utilizing a four-channel or quad-multiplex as the lane of traffic. The transmitting distributor of the synchronous multiplex at the first station is indicated at TD in Fig. 11 and the receiving distributor at the second station at RD in Fig. 12. The distributors are interconnected through the line circuit L arranged for duplex operation in accordance with the usual practice. It will be understood that ordinarily the system is also arranged for transmission from the second to the first station, the apparatus illustrated being duplicated for this purpose.

Referring more particularly to the transmitting apparatus shown in Figs. 10 and 11, the code combinations representing characters to be transmitted over the lane of traffic are stored in the relay bank **80** comprising ten relays (in the case of a five-unit code) having armatures **81** to **90** connected through the armatures of relay **91** to the segments of channels A and B of the transmitting distributor TD or through the armatures of relay **92** to the segments of channels C and D of said distributor, depending upon whether relay **91** or **92** is energized. The relays **91** and **92** are connected to segments **93** and **94** respectively of the local ring **96** of the transmitting distributor TD in such a manner that the relays are alternately energized whereby the characters stored in relay bank **80** are alternately transmitted over first one pair and then the other pair of channels of the transmitting distributor.

The operating windings **97** of the relay bank **80** are multipled to the contacts of the transmitters of the respective channels of the system, such as the tape transmitters **98**, **99**, **101**, **102**, **103** and **104**. The tape transmitters may be similar in construction to that shown in patent to Benjamin No. 1,298,440, dated March 25, 1919, except that transmitters **98**, **99**, **101** and **102** are provided with ten selecting contacts and the stepping magnet of each transmitter is arranged to step the tape two characters at a time whereby, upon each cycle of operation each transmitter is arranged to actuate relays of relay bank **80** in accordance with the code combinations representing two successive characters perforated in the tape. The transmitters may obviously be constructed in various ways to effect the transmission of two or more characters during each cycle of operation. For example, two or more characters might be perforated side by side in a wide tape.

The relays of relay bank **80** are also provided with restoring windings **106** arranged, when energized from segments **107** and **108** of the local ring **96** of the distributor, to restore the armatures **81** to **90** and **81'** to **90'** to their spacing condition. The fourth and ninth relays of relay bank **80** are also provided with operating windings **109** for a purpose to be hereinafter described.

The transmitter **98** is automatically entered on the lane of traffic upon the closure of the autostop contacts **111** controlled by the tape loop adjacent the transmitter. Each of the other transmitters is likewise entered under the control of its associated autostop contacts. The autostop contacts **111** are in series with one-half of the winding of the usual autostop relay **112**, the mid-point of said winding being connected in series with the stepping magnet **113** of the tape transmitter **98**. The autostop relay **112** is normally energized when the associated tape transmitter is inoperative as indicated by the opening of the autostop contacts **111** upon the shortening of the tape loop, the relay being locked up by the right hand half of its winding in series with the stepping magnet of the tape transmitter and through its contact **114** to ground connected to the armature associated with said contact. Upon the lengthening of the tape loop and the resultant closure of the autostop contacts **111**, a circuit parallel to that just described is closed through the left hand half of the winding of relay **112**, the contacts **111**, conductor **1** of cable **116**, contact **117** of remote control relay **118**, conductor **2** of cable **116** and conductor **119** to ground at the contact **142—139** of the transmitting mixer TM. The autostop relay **112** becomes deenergized, the described circuit to ground through the contact **114** is opened and the right hand half of the winding of relay **112** is connected to ground through the contact **181** and the above described contact **142—139** of the transmitting mixer. Thereupon a circuit is closed through the right hand outer armature **182** and back contact of the autostop relay **112** for entering the transmitter upon the lane of traffic in a manner to be described.

Assume that a group of transmitters having a preferred status, as described hereinafter, including transmitters **98**, **99** and **101**, are operative, each having a sufficient quantity of perforated tape to permit the closure of their respective autostop contacts. The stop bars **127**, **127***a*, **127***b*, etc., corresponding to the operative channels, will be in their "channel in" positions as indicated in Fig. 10, and it will be apparent that the rotation of the mixer arm **120** will be stopped at some time by the engagement of said arm with the stop bar **127**. When the local brush **183** engages segment **184** or **186** of the local ring **96** (depending upon whether the previously connected subchannel was connected to channels A and B or C and D of the transmitting distributor), a circuit is closed from battery through the conductor **187**, the right hand armature and back contact of relay **188**, the winding of magnet **135** and the normally closed contacts of relay **189** to ground, whereupon the magnet **135** momentarily depresses the mixer arm **120** to release the same from the latch member **127**. As described in connection with Figs. 1–9 inclusive, the arm **120** then engages the inner end of the pivoted contact **139** and thereby momentarily removes the ground from the circuit of the stepping magnet transmitter **98**, said circuit including the two parallel paths previously traced.

When the stepping magnet of the transmitter **98** is deenergized as described, the feeler pins of the transmitter are projected against the tape and the transmitter contacts are selectively operated in accordance with the characters perforated in the tape. The contacts which are operated into engagement with the upper or marking contacts **191** of the transmitter close circuits through corresponding operating windings **97** of relay bank **80** whereby the code combinations are set up in the relay bank. The breaking of the circuit of magnet **135** by the continued movement of the brush **183** releases the mixer arm **120** which rises above the contact arm **139** as described and rotates into engagement with the stop bar of the next channel which is cut in, in this case **127***a*. The contact arm **139** being biased to closed position, recloses the circuit of the stepping magnet of transmitter **98**, whereupon the feeler pins of the transmitter are withdrawn from the tape and the tape is stepped to present the next two characters to the pins.

Upon the completion of the revolution of the mixer arm 120, the stepping magnet of the transmitter 98 is again deenergized by the actuation of contact arm 139 whereby the transmitter 98 is rendered operative to send two characters over the lane of traffic for each revolution of the mixer arm 120 as long as the stop or latch bar 127 is depressed. Likewise the mixer arm, during such revolution, causes the other transmitters which are cut in by the depression of their latch members corresponding to member 127 to be rendered operative in a predetermined order one after the other, the transmitters having nothing to send being passed by the mixer so that they do not occupy any lane time.

The two characters sent by each transmitter during its operative cycle are set up on the contacts of relay bank 80 comprising ten polar relays each having two unbiased armatures which remain in their operated positions. The armatures 81, 82—90 are arranged to transfer the code combinations received from the respective channels in response to the operation of the mixer alternately to channels A and B of the transmitting distributor TD represented by the first ten segments of the transmitting ring 192 and to channels C and D represented by the eleventh to the twentieth segments of said ring, the change-over from one pair of multiplex channels to the other being effected by relays 91 and 92. The polar relays 193 having their respective armatures connected to the segments of transmitting ring 192 are arranged to store the code combinations from relay bank 80 and impress marking or spacing potential on the segments of said ring so that the characters to be sent over channels A and B of said ring may be set up while the transmitting brush 194 is traveling over channels C and D, and vice versa. As shown, the marking potential of channels B and C is reversed with respect to channels A and D in order that transmission cannot be effected if the transmitting and receiving distributors are accidentally shifted 90°, 180° or 270° out of phase, the out-of-phase relation being apparent from the distorted signals received. Obviously any other out-of-phase condition also interrupts communication.

The transmitters of the respective channels of the expanding channel system may be of any type adapted to operate in conjunction with the lane distributor and are preferably adapted for operation in accordance with characters stored in a tape or other storage medium under the control of the mixer. Each transmitter may be located in a patron's office and adapted to receive tape from a keyboard perforator or may be in the telegraph office and associated with a reperforator controlled from a keyboard transmitter in a branch office of patron's office.

When the transmitter 98 has completed the transmission of the message characters perforated in the tape, the channel is automatically disconnected from the lane of traffic and the lane time is divided between the remaining operating channels. The shortening of the tape loop opens the autostop contacts 111 whereupon the autostop relay 112 becomes energized and locks up in series with the stepping magnet of the transmitter 98, the locking circuit including the inner armature and contact 114 of said relay. After the message characters stored in relay bank 80 from the channel or transmitter preceding transmitter 98 have been transferred to the transmitting distributor storage relays 193, the tongues 81—90 and 81'—90' of relay bank 80 are operated against their spacing or lower contacts by the restoring windings 106 energized from local segment 107 or 108 of the local ring 96.

The subsequent engagement of the mixer arm 120 with the stop or latch member 127 and the energization of magnet 135 operates the contact arm 139 as described above, but the stepping magnet of transmitter 98 does not become deenergized as during transmission from this channel since the stepping magnet is locked up through contact 114 of the autostop relay. Thus the armatures of relay bank 80 remain all spacing and the double-character exit signal in which both characters comprise five all-spacing impulses (blank character) is sent over the lane of traffic to cut out the receiving device of this channel in a manner to be described. The armatures 81'—90' of relay bank 80 constitute baffle circuits which are completed when the entry and exit signals are set up in a bank. Thus when the armatures 81'—90' are all operated to spacing and remain in these positions after the mixer arm 120 has operated contact arm 139 on account of the energization of autostop relay 112 as described, a circuit is closed from battery through the armatures 81', 82', 83', 85', 86', 87', 88', 90', 89', and their respective spacing contacts, conductor 196, cut-out magnet 151 of the transmitting mixer TM, conductor 197, spacing contact and armature 84' to ground whereupon magnet 151 is energized. As previously described, the energization of magnet 151 is instrumental in effecting the movement of the stop bar 127 to its "channel out" position, or to its left hand contact 129 as viewed in Fig. 10. Thus the associated channel is cut out of operative connection with the line of traffic. As the mixer arm 120 rotated, the remaining channels are cut out at the completion of each message in the same manner by the properly timed energization of magnet 151.

The entry of each channel (of which that associated with transmitter 98 is illustrative) upon the lane of traffic as soon as a channel has message characters to transmit its effected automatically in response to the closure of the autostop contacts 111 as a result of the lengthening of the tape loop from the associated perforator or reperforator. A circuit is thus closed from ground through the contact arm 139, conductor 119, conductor 2 of cable 116, contact 117 of relay 118, conductor 1 of cable 116, the autostop contacts 111 and the left hand half of the winding of relay 112 which is in parallel with the circuit through the right hand half of the winding of said relay, and the autostop relay 112 becomes deenergized, thereby removing the locking ground of the inner armature from contact 114 but closing a parallel circuit through contact 181 to the ground at contact arm 139 of the transmitting mixer. Upon the deenergization of relay 112 a circuit is closed from segment 198 of the segmented ring 160 of the transmitting clock TC through the outer armature 182 and back contact of relay 112 to ground at the stop or latch member 127 through the left hand or "channel out" contact 129 which is in engagement with said latch member. When contact arm 158 of the transmitting clock reaches segment 198, the circuit is closed from the grounded segment 198 through contact ring 161 and the winding of relay 188 to battery, whereupon relay 188 becomes energized. When the contact arm 158 engages contact segment 199, a locking circuit is provided through the

latter segment and the left hand armature and front contact of relay 188 whereby said relay is maintained energized for a sufficient time to insure the cutting-in of the channel.

The energization of relay 188 closes a circuit from local segment 184 or 186 when the local brush 183 reaches one or the other of these segments through conductor 187, the right hand armature and front contact of relay 188, conductor 189, coils 109 of the fourth and ninth relays of relay bank 80 and conductor 201, for energizing the cut in magnet 163 of the transmitting clock. As previously described, the energization of magnet 163 depresses the stop bar 127 into its "channel in" position. At the same time, as a result of the energization of coils 109 of relay bank 80, the entry signal is transmitted from the relay bank 80 to one pair of the channels of the transmitting distributor TD and the remote receiving device is cut in upon receipt of this signal in a manner to be described. It will be noted that the diversion of the local pulse from local ring 96 which normally energizes the magnet 135 of the transmitting mixer prevents the transmission of characters from the channel which has been selected by the mixer arm 120 so that the transmission from this channel is delayed during the time required for sending the entry signals over the lane of traffic. Upon the next operating cycle, however, the characters which have been held up will be transmitted, since the mixer arm 120 has not been released from the stop member of the channel which it had selected.

In the embodiment of the invention illustrated, the double entry signal consists of two characters in which the fourth impulse is marking and the remaining impulses spacing ("carriage return" character). The energization of coils 109 of the fourth and ninth relays of relay bank 80 operates the armatures of the fourth and ninth relays to marking, the remaining armatures of the relay bank having been actuated to spacing by the restoring windings 106 in the manner described above.

The double entry signal consisting of two code combinations having the fourth impulse marking has been selected because this selection is ordinarily employed for "carriage return" and if used at all, need not be transmitted twice in succession. Obviously, any desired code combination may be utilized as the entry signal although it is preferred that an entry signal be employed which is not normally used or at least is not required for regular communication. Another useful signal would be an upper case code combination such as "figures shift" followed by "F."

As previously described, entry signals originate at the control apparatus in response to a channel desiring access to the lane. If, however, for any reason a double entry signal originates at a transmitter, means are provided for trapping such a signal, converting it into some other signal before it is transmitted over the line and thereby preventing the false entry of a receiving device for which there would be no corresponding transmitter. Such a false entry signal is detected or read by a relay 202 and, being trapped in this manner, is converted into some other signal combination by the relay 203.

Normally the relay 203 remains deenergized and the armatures 88 and 89 of the relay bank 80 are connected to corresponding segments of the distributor ring 192. But the contacts of this relay are arranged to reverse these connections when the relay is operated, thus altering the signal combination actually transmitted from that set up on the relay bank 80. Under ordinary conditions of traffic or when an entry signal properly originates at the control apparatus, the relay 203 is not energized. However, when the armatures of the relay bank 80 are positioned in response to an entry signal from either the control apparatus or from a transmitter, a circuit, comprising the armatures 81', 82', 83', 85', 86', 87', 88' and 90' engaged with their spacing contacts, and armatures 84' and 89' engaged with their marking contacts, is prepared for the operation of relay 203. This circuit is not completed unless the entry signal is erroneously sent from a transmitter, in which case the impulse which operates the armatures 84' and 89' to their marking contacts also energizes the winding 204 of relay 202 to close the contact 206. Closure of this contact completes the aforementioned circuit, effecting the operation of the relay 203 and thereby rendering the false entry signal nonfunctional for that purpose. It should be noted that relay 202 is provided with a restoring winding 207 whereby the contact 206 is opened before each group of signal combinations is set up in the relay bank 80, thereby preventing the operation of relay 203 whenever a true entry signal is to be transmitted.

Referring to Fig. 12, the receiving distributor RD at the receiving station comprises a receiving ring 400 having the respective segments thereof connected to the windings of the relays of receiving bank 401, and local rings 402 and 403. Each of the relays in the relay bank 401 is a polar relay having two unbiased armatures adapted to remain in engagement with corresponding marking or spacing contacts after each impulse until the reception of an impulse of opposite polarity from the line relay. In this manner the code combinations received over the line are stored upon one set of armatures and the other set is arranged to close baffle circuits when the entry and exit signals are received.

The cable 404 which is multipled to the receiving reperforators or other receiving devices comprises ten conductors which are connected through the armatures of relay 406 alternately to the right hand armatures of the first ten relays of relay bank 401 and to the right hand armatures of the remaining (11th to the 20th) relays of said bank. The relay 406 is energized as long as the distributor brush of the local ring 403 remains in engagement with the segment 407 of said ring whereby the code combinations set up on the second half of the receiving relay bank are connected through the cable 404 to a receiving device while the receiving distributor brush is resetting the first ten relays of said bank, and the last mentioned relays are connected through the back contacts of relay 406 and the cable 404 to another receiving device while the receiving distributor brush is resetting the eleventh to the twentieth relays of said bank in accordance with incoming signals.

The ten selecting windings of a reperforator, printer or other receiving or storing device, are represented at 408, said windings being connected through the individual conductors of a cable 409 to separate contacts 411 adapted to be simultaneously grounded by the pivoted normally open contact member 439 when the latter is engaged by the mixer arm 420 of the receiving mixer RM. If a ten-unit reperforator is employed, it may utilize a wide tape or be arranged to step the tape

two characters during each cycle of operation. The normally open circuits of the other receiving devices are similarly controlled, when the channels are cut in, by the mixer arm **420** under the control of the stop bars **427**, **427***a*, etc. In general, the construction and mode of operation of the receiving mixer RM are similar to the construction and mode of operation of the transmitting mixer TM, the stop bars **427**, **427***a*, etc., being depressed into the path of the rotating mixer arm when the channels are cut in and the mixer arm **420** selecting the operative receiving channels one after the other in the same order and at the same time (taking the transmission lag into account) that the mixer arm **120** of the transmitting mixer selects the corresponding transmitting channels. The receiving devices of the operative channels are operated by momentarily closing the circuits, by the contact member **439**, of the selecting windings **408** and of the usual operating magnet to print, store or perforate the characters set up at that instant on the connected group of relays of the receiving bank **401**.

As has been described above, the entry signal which is transmitted over the line to enter a receiving device on the expanding channel system comprises two successive characters, each having only the fourth impulse marking (double "carriage return"). This signal may be sent over either channels A and B or channels C and D depending upon the time when the clocks TC and RC reach a subchannel which is to be cut in.

Assuming that the entry signal is received on channels A and B of the receiving distributor represented by the first ten relays of the receiving bank **401**, as the brushes of the receiving distributor continue to travel, the circuit of relay **406** is interrupted at the local segment **407** of the distributor. Upon the deenergization of relay **406** during the time when the received signals are being stored in the channels C and D of the receiving bank **401**, a circuit is closed through the upper armature and back contact of relay **406**, through the left hand armatures and marking contacts of the fourth and ninth relays of relay bank **401**, the spacing contacts of the first, second, third, fifth, sixth, seventh, eighth and tenth relays of bank **401**, through the winding of relay **412**, brush arm **458** and segments **461** and **413** of the receiving clock, left hand "channel out" contact **429** and the stop bar **427** to ground, whereupon relay **412** becomes energized.

It will be noted that this circuit is only closed upon the transmission of the entry signal, and the position of the brush arm **458** of the receiving clock, when said signal is received, determines the receiving device which is to be entered on the channel, said device corresponding to the transmitter **98**, Fig. 10, in this instance. The selection of the proper receiving device or channel is thus determined as stated above by the time of transmission of the entry signal. A short signal with interspersed traffic signals is thus operative to select any one of a large number of channels. The lane of traffic is utilized for message signals while the brushes of the clocks move on to the next point of entry which may be hundreds of message characters farther on. The significant lapse of time to effect proper entry is not wasted.

Relay **412** remains locked up through the segment **414** of the receiving clock, the latter circuit including the left hand armature and front contact of said relay. On the continued movement of the brush arm of the receiving distributor RD, a circuit is closed through the local segment **416**, the right hand armature and front contact of relay **402** and the entry magnet **463** of the receiving clock RC. In a manner similar to the entry of a transmitter, the energization of magnet **463** depresses the stop bar **427** into its "channel in" position. As soon as the brush arm **458** of the receiving clock RD leaves the segment **414**, the locking circuit of relay **412** is interrupted and the relay is restored to normal. During the time the relay **412** was energized, the circuit of the operating magnet **435** of the receiving mixer RM was interrupted at the right hand armature and back contact of said relay, thereby preventing release of the mixer arm **420** from the stop bar with which it was engaged.

In this manner the characters forming the entry signal on channels A and B are prevented from reaching a receiving device and the transmitting and receiving apparatus is maintained in synchronism since, as has been described above, transmission of regular character signals over the lane of traffic is momentarily interrupted during the transmission of the entry signal. If the entry signal had been received on channels C and D of the receiving distributor, the operation would have been substantially as described except that relay **406** is energized when the local brush of the distributor engages segment **407** of the local ring **403**, and the baffle circuit for reading the entry signal comprises upper armature and front contact of relay **406** and contacts of the eleventh to the twentieth relays instead of the first to tenth relays of relay bank **401**.

Upon the subsequent engagement of the mixer arm **420** with the stop bar **427**, the selections stored in one half of the receiving bank **401** are connected through the contacts of relay **406** to the windings **408** of the receiving device which is operated by the closure of the contacts **411** and **439** when the mixer arm **420** is depressed beneath the stop bar **427** by the magnet **435**. The circuit of the magnet **435** includes the armature and front contact of relay **417** which is operated as long as any of the stop bars are operated to the right in their "channel in" positions, the right hand armature and back contact of relay **412** and segment **416** or **418** of local ring **402** of the receiving distributor RD. Each of the receiving channels which has been cut in is thus rendered operative concurrently with the corresponding one of the transmitting channels connected successively to the lane of traffic under the control of the transmitting mixer TM irrespective of the number of operative channels, the entire lane time being divided among the operating channels when more than a predetermined number of channels are operative.

In accordance with a further feature of the invention transmission from certain of the transmitters may be made dependent upon the operation of other or regular channels of the system which will be referred to as preferred channels. Thus for example in Figs. 10 and 11 the transmitters **102**, **103** and **104** may be deferred traffic transmitters and arranged to seize a channel of the expanding channel system only when there are none or any other predetermined number of the preferred channels in operation. The deferred channels may be precisely the same as regular channels except that a relay contact is inserted in each of the auto-stop circuits of these transmitters which will bid for entry or exit of the deferred channels when the preferred channels in operation have been reduced to the pre-

determined number. The auto-stop circuit for the transmitter 102 includes a contact 208 of relay 209 for the above described purpose. It will be understood that this relay will have similar contacts for each of the other deferred channel transmitters. Transmitters 103 and 104 having different tapes are five-unit transmitters arranged to operate in unison on one expanding channel. Corresponding five-unit receiving devices may be employed at the receiving end of such an expanding channel.

Associated with the stop bars 127, 127*a*, etc. of the transmitting mixer TM are individual contacts 211 which are connected to separate resistances 212, 213 and 214. Resistances 212 which are associated with preferred channels have a common terminal which is connected through the operating windings of relays 209, 216, 217 and 189. It will be apparent that the current through these relays varies according to the number of preferred channels which have been cut in. Similarly, resistances 214 have a common terminal which is connected only to the windings of relays 217 and 189. Thus, it is seen that the current through the windings of relays 209 and 216 is always in direct proportion to the number of preferred channels which are cut in, whereas the current through the windings of relays 217 and 189 is in direct proportion to the total number of channels cut in including both preferred and deferred channels. The relay 209 is arranged to remain operated as long as one or more preferred channels is cut in and to release when there are no preferred channels cut in. The relay 217 is adapted to close a contact when the number of operative channels is less than three. Similarly, the relay 189 is adapted to close a contact when one or more channels is cut in.

When no channels are cut in, the armature of relay 189 remains on its right hand contact and the mixer arm 120 spins freely without being depressed by the armature of magnet 135, thus preventing the actuation of any of the contact arms 139. When any stop bar such as bar 127 is moved to the channel-in position by the clock mechanism, a circuit is established through the operating winding of relay 189, the left hand resistance 212, through the right hand contact 211 and the stop bar 127 to ground. Positive battery is applied to the other terminal of the winding of relay 189, the circuit for which may be extended to a remote point such as an operating position or a subscriber's office and carried through a meter or similar indicating device 218 for a purpose to be described. Relay 189 is provided with a biasing circuit which has a tendency to move the armature to its right hand contact. However, the current which is conducted through the operating winding of this relay by means of the described circuit when one or more channels is cut in, is sufficient to overcome the effect of the biasing circuit and move the relay armature to its left hand contact, thereby preparing the operating circuit for magnet 135. Thus the mixer arm of the transmitting mixer resumes its regular function when the first channel is entered.

If several channels are in operation at once, the speeds of the various expanding channel transmitters are comparatively slow. Let us assume that three channels of the first station give a satisfactory rate of operation for each channel, even though the multi-lever transmitters were capable of keeping the circuit completely full. In that case the one busy operator would find it extremely difficult to keep the line full of traffic and therefore it is desirable to limit the speed of operation of the channel transmitters when the number of channels cut in is less than three. Relay 217 is also provided with a biasing circuit having a tendency to move the armature 219 to its right hand contact. However, when three or more transmitters are cut in, the preponderance of current through the operating winding of this relay maintains the armature on its left hand contact. With two transmitters cut in on the expanding channel system, the biasing circuit of relay 217 becomes effective to move the armature of this relay to its right hand contact. The armature of this relay is connected by means of conductor 13 of cable 116 through an armature and back contact of relay 118 to ground. As soon as armature 219 engages its right hand contact, this ground is applied to a conductor 281 which is connected to the front contacts associated with the outer armatures of all of the auto-stop relays such as armature 182 of relay 112 and armature 282 of relay 283.

If it be assumed that relay 283 is energized and locked in a manner similar to that described for relay 112, armature 282 extends the ground connected to its front contact to segment 284 of the transmitting clock TC. Similar segments associated with all of the transmitters which are disabled by reason of the fact that their associated auto-stop relays are operated, are grounded by the operation of relay 217. The grounding of these segments results in the movement of one of the stop arms 127*a*, 127*b*, etc. into its channel-in position as described. Consequently the stop bar corresponding to one of the cut-out channels is actuated as if the channel were being entered upon the system for communication purposes and since the transmitting mixer TM does not step to a new position during the entry function, the rate of transmission for the operating channels is curtailed. Thus, the relay 217 constitutes a kind of governor device on the regular channels which remain in operation.

As soon as one of the stop bars 127 is actuated to its channel-in position by the operation of relay 217, ground is applied to another one of the resistances 212, 213 and 214 which results in an increase in the current through the operating winding of the governor relay 217. Since at this time there are again three of the stop bars in their channel-in positions, the operating current of relay 217 is greater than the biasing current and the armature 219 is moved to its left hand contact. When the mixer arm 120 reaches the stop bar associated with the inoperative channel which has been actuated in response to the action of the governor relay, an all spacing signal combination is sent from this transmitter since its stepping magnet remains locked up under the control of the associated autostop relay and the stop bar is moved to its channel-out position in the manner previously described. If in the meantime there have been no additional channels entered, the armature 219 of the relay 217 will again be moved to its right hand contact and the above described cycle of operations will be repeated. It will be noted that when the stop bars associated with the deferred channel transmitters are actuated to their channel-in positions by the action of relay 217, no transmission occurs from these transmitters even though there may be an appreciable accumulation of tape awaiting transmission so that their

associated autostop contacts are closed. These channels cannot be entered for the transmission of traffic until their respective autostop circuits are completely closed. These circuits are arranged to be closed only when there are no preferred channels in operation. For example, the autostop circuit for transmitter 102 is extended by conductor 7 of cable 116 through a back contact and armature of relay 118 to conductor 8 of cable 116 and this circuit stands open at contact 208 of relay 209.

When none of the preferred channels is in operation the current through the winding of relay 209 is reduced to zero permitting the armatures of this relay to move to their respective back contacts. The autostop circuits for all of the deferred channel transmitters are carried through contacts of relay 209. Consequently it is seen that as soon as the preferred channel transmission has ceased, all of the deferred channel transmitters having tape prepared for transmission are given an opportunity to be entered on the system. For example, if it be assumed that transmitter 102 is supplied with a quantity of tape so that its autostop contacts are closed, the closure of contact 208 of relay 209 completely closes the circuit of the autostop relay whereby this relay is released and its associated transmitter placed under the control of the transmitting mixer TM. The stop bar corresponding to this channel is moved to its channel-in position as described and transmission is effected over this channel by the operation of the transmitting mixer arm 120. In a similar manner all other deferred channels having traffic to send are entered and the deferred traffic is carried over the system as long as there are none of the preferred channel transmitters desiring entry on the system.

Deferred channel transmitters 103 and 104 are of the standard five-contact variety and though employed in transmission of two separate messages their magnets are in series and their operation is in all respects equivalent to that of the other transmitters. At the receiving end the devices for receiving impulses transmitted by the transmitters 103 and 104 may be the usual five unit printers or reperforators both connected to one group of contacts of the receiving mixer. The governing action of relays 189, 217 and 209 and their associated circuits need not be repeated at the receiving end in connection with the receiving mixer RM and the receiving clock RC as the time consumed in the cut-in and deferred channel functions are identical in all respects to those employed for the operation of the regular channels.

Another important feature of the invention is the metering or service charge arrangement which is made for the customers having transmitting apparatus in a system of this nature. Several forms of metering arrangements are shown in this application. In one form the metering device is a counter 286, the operating circuit for which is connected in series with the operating circuit of the stepping magnet 113 of transmitter 98. The counter may be a conventional electro-magnetic register having counting wheels operated by the successive energization and deenergization of the operating magnet. Thus, every time the transmitter stepping magnet is deenergized and subsequently energized for the transmission of message characters, the number of such characters is automatically registered on the meter 286. In this manner the customer may be billed for the actual number of message characters transmitted irrespective of the time required to send these characters. Such a metering arrangement is desirable, particularly on channels providing a preferred service, since it is a characteristic of this system that the line time is shared equally among the operating channels. Obviously the time required to transmit a given number of characters will vary in direct proportion to the number of channels which are operated over the line. The billing of a customer on the basis of a character count is therefore more equitable than charging him solely on the basis of the length of time he is connected to a circuit.

Another metering arrangement is one by which a customer may be billed in accordance with the total number of characters transmitted, the charge for each character being weighted in accordance with the busy condition of the line. It will be apparent that when a large number of channels is operating over the line a given portion of the line time is more valuable than the same portion taken at a time when the line is comparatively idle. Consequently it may be desirable in some cases to provide a subscriber with a type of metering service whereby he can select the maximum rate which he is willing to pay for the transmission of his traffic. For this purpose such a channel is provided with a meter 287 which may be similar to a conventional integrating watt hour meter. One of the windings 288 of this meter is connected in series with relays 217 and 189 whereby the current is in direct proportion to the number of operating channels. A second winding 289 is connected to a make contact 291 on the transmitting mixer TM. With this arrangement every time the mixer arm 120 engages the contact arm 139*d* to actuate the deferred channel transmitters 103 and 104, a circuit is closed through the make contact 291 and through winding 289 of the meter 287. Thus, successive operations of these transmitters produce a series of impulses through winding 289 of the meter. Both meter windings have a cooperative action on the register mechanism and since the current through the winding 288 is in proportion to the number of channels which are entered, the series of impulses through winding 289 is weighted in proportion to the busy condition of the line. It will be noted that the winding 288 of the meter 287 is connected in series with the windings of relays 209 and 216 when the armatures of relay 209 are in engagement with their front contacts so that the current flowing in this series circuit is proportional only to the number of preferred channels which are entered. However, when there are no preferred channels in operation the armatures of relay 209 are released and the winding 288 of relay 287 is connected to a fixed potential so that the current through this winding will have a fixed minimum value which may be considered as a minimum rate given to deferred channels.

A subscriber may be given an opportunity to select the maximum rate to be paid for the transmission of his traffic and for such purpose is provided with a relay 216 having an operating winding which is connected in series with the multipled resistances 212 associated with preferred channels. This relay also has a biasing winding 292, which is connected to positive potential through the winding of a relay 293 and is extended to the subscriber's office or remote

operating position where it is connected through a meter or equivalent device **294** and through a rheostat **296** to ground. Relay **216** has contacts which are inserted in series with the auto-stop relay associated with the channel transmitter. The tendency of the biasing circuit of the relay is to move the relay armatures to their respective right hand contacts. The current through the operating winding, on the other hand, has a tendency to move these armatures to their respective left hand contacts. The result of this arrangement is that whenever the current in the biasing circuit becomes greater than that in the operating circuit, the auto-stop circuit is closed and the channel entered on the system. The subscriber is given control of the biasing current through the rheostat **296**. He is also provided with an indication of the busy condition of the expanding channel system by means of the meter **218**.

Assume that there are eight preferred channels operating over the system and that a subscriber who is given a choice of rates has traffic which he desires to transmit. However, the maximum rate which he is willing to pay is one which is based on the utilization of the lane by six channels. The meter **218** indicates a rate which is based upon the fact that there are eight channels operating at the time. The subscriber adjusts the rheostat **296** so that the indication on meter **294** is in accordance with a six channel operation over the lane of traffic. In making this adjustment, the subscriber adjusts the biasing circuit of the relay **216** so that when the number of preferred channels is reduced to five the biasing circuit of the relay becomes effective to move the armatures to their right hand contacts. The engagement of armature **297** with its right hand contact closes the auto-stop circuit and prepares for the entry of the channel as described. The engagement of armature **298** with its right hand contact connects an auxiliary winding **299** into the biasing circuit. The purpose of this increase in the biasing circuit of the relay is to prevent the restoration of the armatures to their left hand contacts when the channel is entered and that fact is registered by the movement of its associated stop bar to its channel-in position whereby the current through the operating winding of the relay **216** is increased. The additional biasing given to this relay is only sufficient to compensate for the entry of one additional preferred channel, which in this case is the channel of the subscriber desiring entry at this point. It is thus seen that there are now six channels in operation and as soon as one or more other preferred channels is entered, relay **216** operates its armatures to their left hand contacts and the channel controlled thereby is disconnected from the expanding channel system until such time as conditions again become favorable for entering the channel.

Thus it is seen that a subscriber who is provided with means for choosing the maximum rate which he is willing to pay for transmitting his traffic is entered on and remains connected to the system as long as the channel cut-in conditions are such that his rates do not exceed a maximum value. With an arrangement of this nature such a subscriber is also provided with means to take advantage of any lower rates if the number of channels is decreased. For example, if the maximum rate chosen is based upon the operation of the expanding channel system with six channels operating and one or more of the operating channels is cut out the value of the current in the winding **288** of the recording meter **287** is reduced accordingly. The effect of this reduction is that the characters counted by such a meter are given less weight and the totals registered by the meter are correspondingly less. Thus, a subscriber may choose the maximum rate at which he will be billed for the transmission of his traffic and at the same time will be able to obtain the advantage of any prevailing rate under the pre-selected maximum.

The constants of the circuits of relay **216** are adjusted so that a subscriber, by moving the arm of the rheostat **296** to its extreme left hand position, may be given an unqualified preferred status irrespective of the number of other preferred channels which may be cut in. In this case the current through the biasing circuit of relay **216** is in excess of the maximum current in the operating circuit so that the armatures of this relay are permanently engaged with their respective right hand contacts and the transmitter associated with this channel is given a status equal to that of the preferred channel transmitters **98**, **99** and **101**. Hence, whenever such a subscriber has material to be transmitted, his channel is immediately cut in on the system and the line time is shared among this channel and any other preferred channels which may also be cut in at this time. It will be noted, however, that the rate which is charged such a subscriber is based upon the number of characters transmitted and the busy condition of the system. It is obvious that as other preferred channels are cut in and cut out of the system during the connection of such a channel this rate will fluctuate.

In series with the biasing circuit of relay **216** is the winding of a relay **293**, the armature of which is connected to the resistance **213** associated with the mixer stop bar corresponding to this channel. The relay **293** is adapted to maintain this armature in engagement with this front contact so long as the current is sufficient to prevent the operation of the armatures of relay **216** to their right hand contacts while one or more preferred channels is cut in. The front contact of relay **293** is connected to the common terminal of the resistances **212** so that as long as relay **293** is operated the resistance unit **213** is included in the group of preferred channel resistances. Hence, the release of relay **209** while any of the preferred channels, including the channel having control of its maximum rates, is prevented thereby preventing the operation of any of the deferred channels. However, when the subscriber moves the arm of his rheostat **296** to its extreme right hand position, he elects to defer the transmission of his traffic until such time as there are no preferred channels in operation and the group of deferred channels is given an opportunity to send. This manipulation of the rheostat adjusts the current through relay **293** so that its armature is released to its back contact. Now it is seen that the resistance **213** is switched to a connection with the common terminal of the deferred channel resistances **214**. Under these conditions transmission from transmitters **103** and **104** can occur only when there are no preferred channels in operation. For this class of service a fixed minimum rate may be charged for the transmisison of the deferred subscriber's traffic. It was previously seen that the armatures of relay **209** were released

to their respective back contacts for the operation of deferred channels. Hence the fixed minimum rate which is charged the subscriber utilizing transmitters 103 and 104 is provided by adjusting the current through winding 288 of the meter 287 to a fixed minimum.

Another equitable basis for the rates which are charged for the transmission of the subscriber's traffic is recording the time that he is associated with the expanding channel system. This arrangement recognizes the fact that the rates should be a function of the number of characters transmitted and of the busy condition of the system. A subscriber having a given number of characters to transmit will be able to move this traffic over the system faster when the system is relatively idle than when it is busy. Since the line time required to transmit one character during a busy condition of the system has a greater value than the time required to send a character when the system is lightly loaded, a record of the time during which a channel is connected for operation will provide a fair basis for charging the subscriber. Such a metering arrangement is provided for one of the channels by connecting in series with one of the resistances 214 the winding of a relay 301. Whenever the channel associated with this resistance is entered upon the system, relay 301 is energized. The engagement of the armature of this relay with its front contact closes a contact from a source of power to a metering device 300. Such a device may be similar to a conventional self-starting synchronous electric clock. The dial of the device may be graduated in any convenient manner so that the indication is in proportion to the time that the subchannel is connected to the system. It will be obvious to those skilled in the art that the metering device 300 may be arranged to integrate over any desired period of time so that the total time taken over a substantial period, during which the channel is connected to the system may be obtained.

It is obvious that any of the forms of metering devices shown herein may be employed individually or in combination with one another for either or both of the preferred and deferred service in order to meet any particular service requirement. It is contemplated that all such combinations be considered as coming within the scope of the instant invention.

It is desirable in a system of this character to provide auxiliary signaling or control channels in addition to the channels used for communication. These auxiliary channels may be used for various purposes such as signaling between the attendants at the respective offices or for controlling the operation of the equipment in any desired manner. Thus, if difficulty is experienced in reception at one office it may be desirable to stop transmission into that office. If desired the controlling channel may be used, for example, to stop the apparatus and reconnect the operative channels one by one from an inoperative condition to insure that the same number of transmitting and receiving channels are in operation. In the system shown these signaling or control channels are provided with space on the transmitting and receiving mixers as in the case of each of the communication channels.

If the attendant at the station shown in Figs. 10 and 11 wishes to stop transmission coming into that station from the station shown in Fig. 12, he operates a switch or key 302 to its left hand position thereby applying ground to segment 303 of the transmitting clock TC. When the arm 158 of the clock reaches this segment a stop bar 127*g* is moved to its channel-in position and an entry signal transmitted over the line to the receiving apparatus of Fig. 12. At this station a corresponding stop bar 427*g* is moved to its channel-in position against its right hand contact thereby applying a ground to energize a relay 118'. This relay corresponds to relay 118 of the transmitting station which carries contacts that control the autostop circuits of all of the transmitting equipment and a signal such as a bell 304 to call the attention of the attendant to the fact that his transmission is being interrupted. These control circuits are shown in detail in Fig. 10 and since it is understood that the system is arranged for full duplex operation and each station is supplied with both transmitting and receiving apparatus it will be understood that the operation of relay 118' is effective to interrupt all transmission from the station of Fig. 12 to the station of Figs. 10 and 11. The opening of the autostop circuits of the transmitters results in the movement of all of the stop bars associated with operative channels to their channel-out positions. When the transmitting mixer TM engages the contact arm associated with the signaling channel an all-spacing character is transmitted, since there is no apparatus associated with this arm, and the stop bars of the signaling channel are also moved to their channel-out positions. This may occur immediately following the entry of the signaling channel on the system since there is no time relation between the clock arms and the mixer arms. However relay 118' is arranged to maintain the armatures in an operated condition for a period of time sufficient for the mixer arms to make a complete circuit irrespective of the number of channels which may be operating. This slow-to-release characteristic of this relay may be obtained in any well known manner. As soon as the armatures of this relay are released to their back contacts following the movement of all of the stop bars to their channel-out positions, the operative transmitters are again entered on the system one at a time. Since it is assumed that the multiplex apparatus is in synchronism, the transmitting and receiving clocks are also in step with one another and the entry of the channels of the system will necessarily be correct.

The operation of an auxiliary signaling channel in accordance with the foregoing description requires that an entry signal and an exit be sent over the lane of traffic. If, at the receiving station of Fig. 12, the stop bar 427*g* is arranged in the manner of the stop bar 27' of Fig. 4, it will be moved to its channel in position to energize the relay 118' in response to a received entry signal and, immediately thereafter, moved to its channel out position by means of the retractile spring. In this case it is obvious that valuable lane time will not be used for the transmission of an exit signal for an auxiliary signalling channel provided with such facilities. Consequently, at the transmitting station, the auxiliary signaling channel need not be equipped with a stop bar on the mixer. It will be understood by those skilled in the art that such a channel may be used for any desired form of signaling between the attendants at the terminals of such a system. For example, the relay 118' instead of controlling the auto-stop circuits of

the transmitters of the system may be employed to control a bell or any other type of signal.

The stop bar **427***g* may also be similar to the stop bar **27''** of Fig. 3. In this case, once it has been moved to its channel in position in response to a received entry signal, the circuit controlled thereby remains closed, thereby maintaining in operation any signal devices connected thereto until an attendant responding to the signal device restores the stop bar manually to its channel out position. Also, it is seen with this type of stop bar no exit signal transmitted over the lane of traffic is required and no stop bar is needed on the mixer at the transmitting station.

Provisions are also made in this system to check periodically the channels connected to the system. Such a check is made over a second control channel by the closure of a contact **305** effected by the engagement of the transmitting clock cam **170** with its associated follower **171**. Ground is thus applied to segment **306** of the transmitting clock and a stop bar **127***f* is moved to its channel-in position. The entry of this channel is similar to that of any of the communication channels so that at the receiving station a corresponding stop bar **427***f* is moved to its right hand contact corresponding to the channel-in position of this bar. If the multiplex apparatus is in synchronism, the transmitting and receiving clocks are in step and the movement of the stop bar **427***f* to its right hand contact occurs at a time when the receiving cam follower **473** is about to be engaged by the depressed portion **477** of the cam **468***b*. At this time the follower **473** is disengaged from both of its contacts. As soon as the engagement with the depression **477** occurs the follower is engaged with its lower contact. It will be noted that a connection is made from the cam follower contact **473** to one side of the winding of relay **481** which is connected in series with the winding of relay **118'** and to positive potential. The engagement of the cam follower contact **473** with its lower contact is ineffective at this time since the stop arm **427***f* is engaged with its right hand contact. Further movement of the cam **468***b* restores the follower contact **473** to its intermediate position in which it stays for a period of time sufficient for the transmitting and receiving mixer arms to make a complete revolution when all of the channels are entered on the system. The purpose of such an arrangement will be described in greater detail in a subsequent portion of the specification. The fact that relays **481** and **118'** were not operated at the time that the cam follower contact **437** engaged its lower contact is an indication that the multiplex apparatus and the clocks are in synchronism.

During the time that the contact **473** is held in its intermediate position following its engagement with its lower contact, the mixer arms will reach the stop arms associated with the control channel. At the transmitting station the engagement of mixer arm **120** with the contact arm **139***f* releases relay **307**. The inner left hand armature of this relay connects through its back contact positive potential to one terminal of the winding of the exit magnet **151**. The engagement of the outer armature of this relay with its back contact connects a ground to the other terminal of this magnet winding. The energization of the exit magnet at this time moves the stop bar **127***f* to its channel-out position. The engagement of the other armatures of relay **307** with their respective back contacts sets up a signal in the relay bank **80** for transmission to the remote station. The signals sent under these conditions are preferably different from the entry and exit signals used for the communication channels and they also should be signals of a character or function which does not occur twice in succession in ordinary traffic. For the purposes of this description the character Y has been chosen. If the system is found to be operating correctly by the periodic check so that the transmitting and receiving mixers as well as the clocks are in step, the receiving mixer arm **420** will be engaged at this time with the contact arm **439***f* associated with the receiving end of the control channel. Hence the double Y signal combination which is received is applied to a receiving bank of relays **482**. This relay bank is equipped with a set of contacts which are interconnected in such a manner that the reception of the double Y connects the ground of the lower armature through the reading circuit to the right hand contact of the upper set of contacts to operate relay **483**. Relay **484** is also operated by the engagement of the contact arm **439***f* with its associated contacts. Hence, a circuit is established from battery on the front contact of relay **483** through its armature and the front contact of relay **484**, through its armature to the winding of the exit magnet **451**. In this manner the stop bar **427***f* is moved to its channel-out position against its left hand contact. It will be remembered that at this time the contact follower **473** is being held in its intermediate position so that there is no operation of relays **481** and **118'**.

Thus it is seen that the operation of the periodic checking mechanism controlled by the cam apparatus associated with the transmitting and receiving clocks results only in the simultaneous entry of the transmitting and receiving portions of the control channel and also the subsequent exit of the control channel. The gearing on the respective cams is such that this periodic check is made once in every several revolutions of the clocks depending upon the requirements of a particular circuit. This period may correspond to the time required to send as many as several hundred characters. It has been shown that, with the system operating properly, the entry and exit of the control channel is ineffective to produce any change in the system. However, there are several conditions under which the periodic checking function is effective to interrupt the operation of the system when it is found to be operating abnormally.

If the multiplex apparatus is out of synchronism so that the transmitting and receiving clocks are not in step, the entry of the control channel from the transmitting end of the system will not connect the receiving apparatus of this channel. Consequently at the receiving station the stop bar **427***f* will be engaged with its left hand or channel-out contact at the time that the cam **468***b* reaches the point where the follower contact **473** is moved into engagement with its lower contact. In this case the ground which is connected to the stop arm is connected through the lower contact and the follower **473** to the operating circuits for relays **481** and **118'**. The operation of the latter relay discontinues transmission from the station shown in Fig. 12 to the station shown in Figs. 10 and 11 and the

channels operating in this direction are disconnected as described. The operation of relay 481 applies a ground through the normal contacts of a switch 302', corresponding to switch 302 at the other station. Thus, operation of this relay is effective to initiate a control signal which, when received at the station shown in Figs. 10 and 11, operates the remote control relay 118. Since a similar function has been described in detail, the performance of this function in the opposite direction from that described is shown diagrammatically. The reception of the control signal at the other end of the circuit energizes the receiving entry magnet 463' to move the stop bar 427*g'* which in turn operates the relay 116 to disconnect the transmitting apparatus. It may be that with the multiplex apparatus out of synchronism, this transmitted stop signal will not be properly received at the station shown in Figs. 10 and 11. However, this communication channel is also provided with periodic taking facilities which will operate as described to stop transmission in the other direction also. The receiving portion of such apparatus is shown fragmentarily and includes the cam 463*b'*, which operates the contact 473' which in conjunction with stop arm 427*f'* controls the operation of relays 481' and 118. Armatures 308 and 309 indicate diagrammatically the operation of the reading relay bank 482' to control respectively the operation of relays 481' and 118 and the exit magnet 451'. If desired, the periodicity of the tests made over both channels of the duplexed circuit may be different to guard against circuit failures which may cause one station's transmission to be received by the same station.

With the transmitting and the receiving clocks out of synchronism it may be that in response to an entry signal the control channel stop bar 427*f* is moved to its channel in position in place of a regular communication channel. This may occur at any time while the cam follower 473 is bearing on the raised portion of the cam so that the follower is engaged with its upper contact. It is seen that the movement of the stop bar 427*f* to its right hand contact in response to a false entry signal connects a ground through the cam contacts to the operating circuits of relays 481 and 118' thereby stopping transmission in both directions and disconnecting all channels from the system. At the expiration of a period of time long enough to effect the disconnection of all channels, relays 481 and 118' are released thereby permitting the reconnection of all channels.

The channel arrangement of the system may also be incorrect without the multiplex apparatus being out of synchronism. That is, the transmitting and receiving clocks may be in step with one another but for one reason or another the transmitting and receiving mixers may be out of step. Such a condition may arise from a variety of different circumstances such as the connection of more channels at one end of the system than at the other, etc. The fact that the transmitting and receiving clocks are in step means that when the periodic test is initiated by the connection of the control channel to the system, stop bar 427*f* will be moved to its channel-in position at the proper time. But because the transmitting and receiving mixers are out of step the receiving mixer operates the contact arm 439*f* of the control channel at the time that the transmitting mixer arm is sending communication characters from one of the regular channels. These characters are applied to the relay bank 482 and their respective armatures are moved to one or the other of their contacts in accordance with the received character combination. Since the character combination is something other than a double Y, one or more of the armatures of this reading bank will be moved to a contact connected to a conductor 486. Consequently the ground connected to the lower armature of the relay bank is connected to the conductor 486 and to the operating windings of relays 481 and 118'. Thus it is seen that an abnormal condition of this character is also detected by the checking apparatus provided and the operating channels are disconnected from the system and subsequently reconnected one at a time.

The operation of the reading bank of relays 482 is also effective to detect a condition wherein the stop bar 427*f* of the control channel is erroneously moved to its channel-in position. Such a condition may be the result of the mutilation of a character signal when it is being transmitted over the line in such a manner that it is transformed into an entry signal. Consequently such a signal is utilized at the receiving end for the purpose of entering whatever channel happens to be associated with the receiving clock at the time that the signal is received. Obviously no harm will be done if this channel is one which is already entered on the system but if the channel which is entered under these conditions is the control channel this fact is detected by the first character which is received on this channel. The receiving circuits of the relay bank 482 operate for this purpose in a manner similar to that described.

The nature of the invention may be ascertained from the foregoing description of an illustrative embodiment, it being understood that changes in the invention herein disclosed may be made within the scope of what is claimed without departing from the spirit of the invention.

What is claimed is:

1. An expanding channel telegraph system comprising a plurality of communication channels and means whereby at least a part of the transmitting time of an idle channel is utilized by another channel, a lane of traffic shared by operative channels, means for integrating the message characters sent on each channel, and means for weighting the integrated characters in accordance with the busy condition of the lane of traffic.

2. An expanding channel telegraph system comprising a plurality of channels and means whereby at least a part of the transmitting time of an idle channel is utilized by another channel, a lane of traffic shared by operative channels, means for registering the number of message characters transmitted on each channel, means for registering the frequency of transmission of said message characters, and means for combining the registered information.

3. A telegraph system comprising a plurality of channels, control means for said channels whereby the rate of transmission of message characters on any channel is dependent upon whether more or fewer other channels are in operation, means for metering the traffic on said channels on the basis of the number of characters transmitted and a variable scale of charges per character, and means for varying said scale of charges in accordance with the number of channels in operation.

4. In a telegraph system comprising a plurality of channels, control means for said channels whereby the rate of transmission of message characters on any channel depends upon whether more or fewer other channels are in operation, a two-element electric device for metering traffic on said channels, means including one of said elements for integrating the number of message characters transmitted, and means including the other of said elements for integrating the number of channels operating over the lane of traffic.

5. A telegraph system comprising a lane of traffic, a plurality of communication channels, means for operatively associating with said lane of traffic those of said channels having message characters to transmit, each operative association being only for a period required to transmit said characters, control means whereby the rate of transmission of message characters on any channel operatively associated with said lane of traffic depends upon the number of other channels operatively associated with the lane of traffic, and mean for timing the periods of the operative association of each channel with the lane of traffic.

6. A system of communication comprising a lane of traffic, a plurality of communication channels, control means for apportioning the transmitting time of said lane of traffic among those of said channels having signals to transmit, and metering means for determining the proportional part of the transmitting time of said lane of traffic utilized by each of said channels during a period of time, said metering means including a timing device associated with one of said channels and rendered operative only during the signal transmitting intervals of its associated channel.

7. A system of communication comprising a lane of traffic, a plurality of communication channels, control means for dividing the transmitting time of said lane of traffic among operative channels, and means for metering traffic on said channels on the basis of the number of characters transmitted and the proportional part of the transmitting time of said lane of traffic utilized by said channels, said metering means including a unitary integrating device having two cooperative elements, one responsive to the number of characters transmitted and the other responsive to the busy condition of the lane.

8. A system of communication comprising a lane of traffic, a plurality of communication channels, control means for dividing the transmitting time of said lane of traffic among operative channels, means for metering traffic on the basis of the number of characters transmitted, means for determining the rates to be charged for said metered traffic on the basis of the utilization of said lane of traffic by the operative channels, and means for rendering operative one of said channels when the rates do not exceed a predetermined maximum.

9. An expanding channel telegraph system comprising a plurality of channels and means whereby at least a part of the transmitting time of an idle channel is utilized by another channel, a lane of traffic shared by operative channels, means for metering traffic on the basis of the number of characters transmitted, means for determining the rates to be charged for said metered traffic on the basis of the utilization of said lane of traffic by operative channels, means for pre-selecting the maximum rate for the traffic of one of said channels, and means for rendering operative said one channel when the rates do not exceed the pre-selected value.

10. The invention as defined in claim 9 further characterized by means for varying the rate of said one channel when operative in accordance with the utilization of the lane of traffic by the operative channels.

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