July 22, 1947. H. D. COLMAN 2,424,223

MESSAGE INTERCEPTING AND RELAYING CIRCUITS IN AN AUTOMATICALLY DIRECTED MESSAGE TELEGRAPH SYSTEM

Original Filed July 19, 1940 28 Sheets-Sheet 1

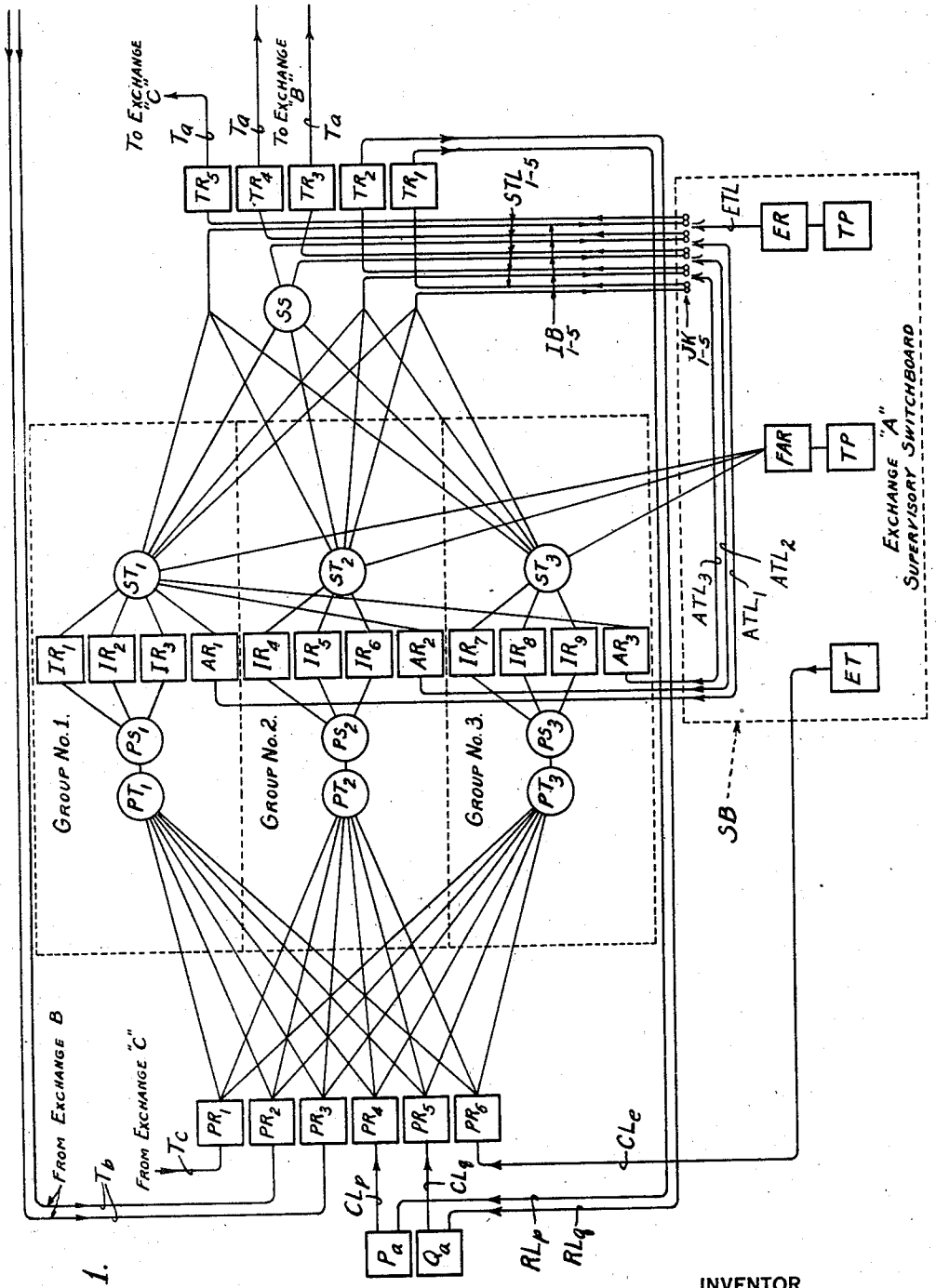


Fig. 1.

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HARRY A. SEVERSON, HIS EXECUTOR
BY William F. Simpson.
ATTORNEY

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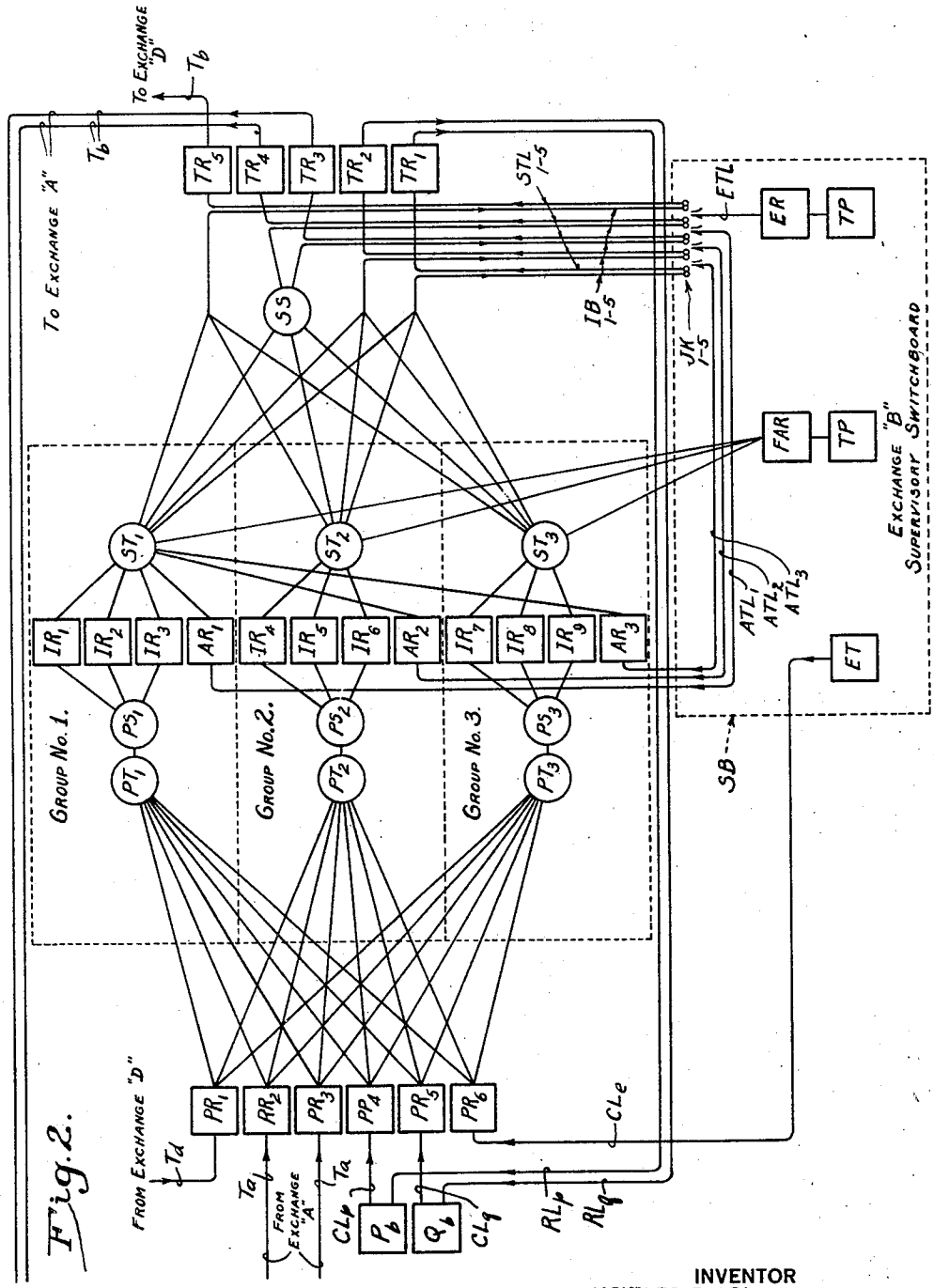


Fig. 2.

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Fig. 3.

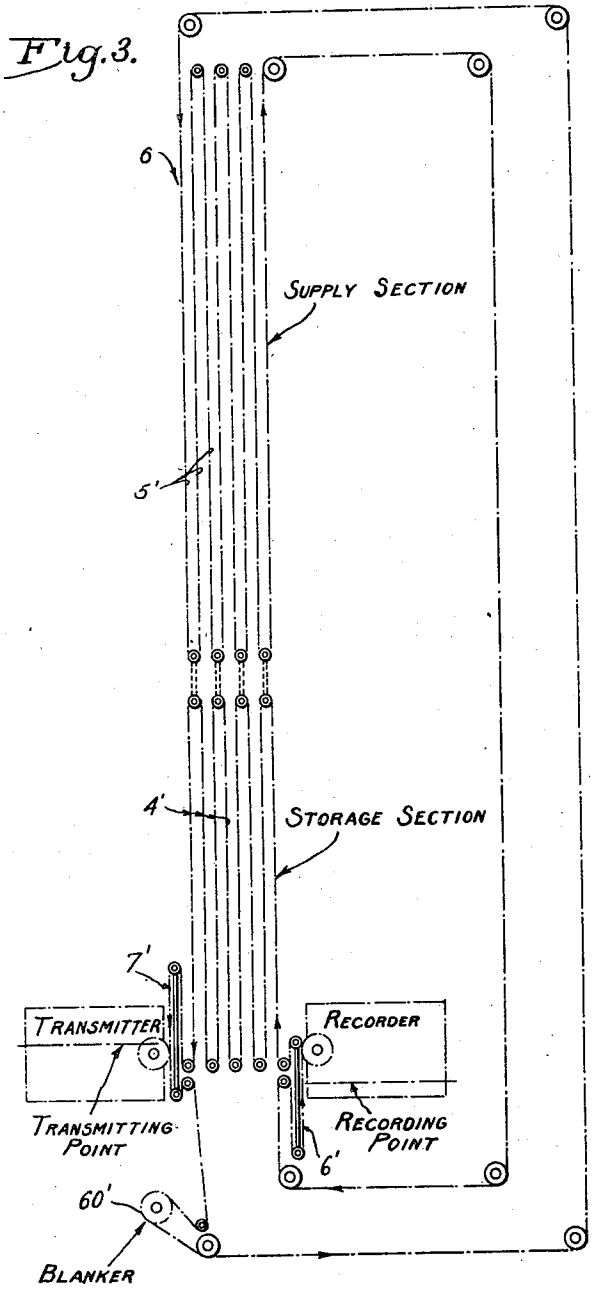


Fig. 32.

Fig. 21.	Fig. 22.	Fig 23
Fig. 24.	Fig. 25.	Fig. 26.
Fig. 27.	Fig. 28.	Fig. 29.
	Fig. 30.	Fig. 31.

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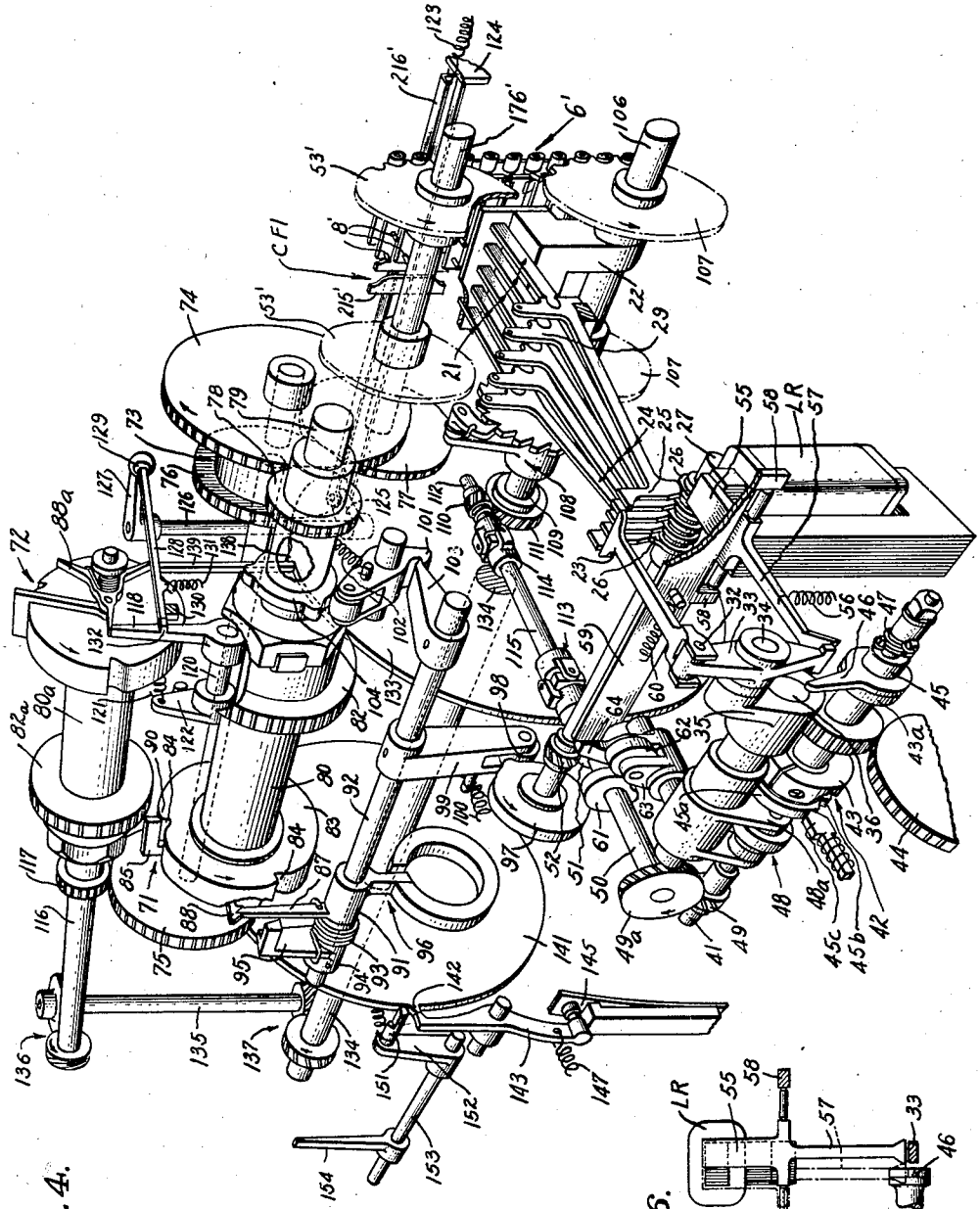


Fig. 4.

Fig. 6.

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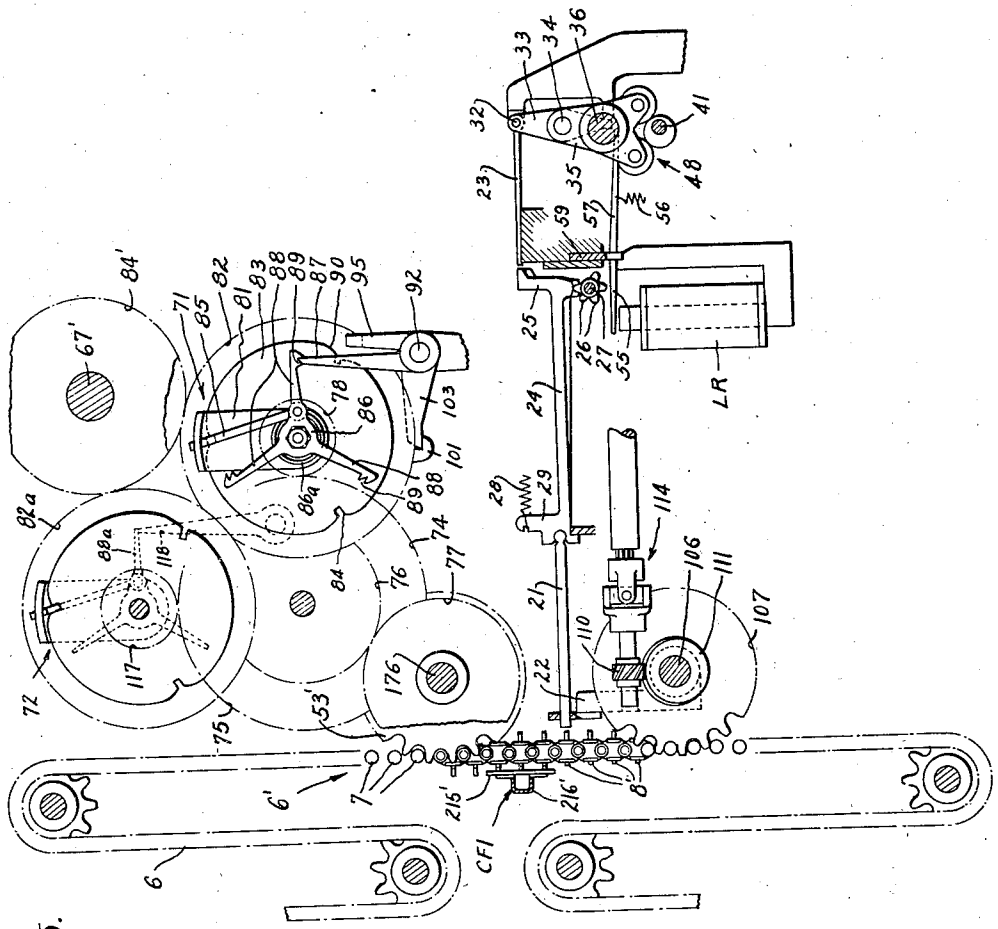


Fig. 5.

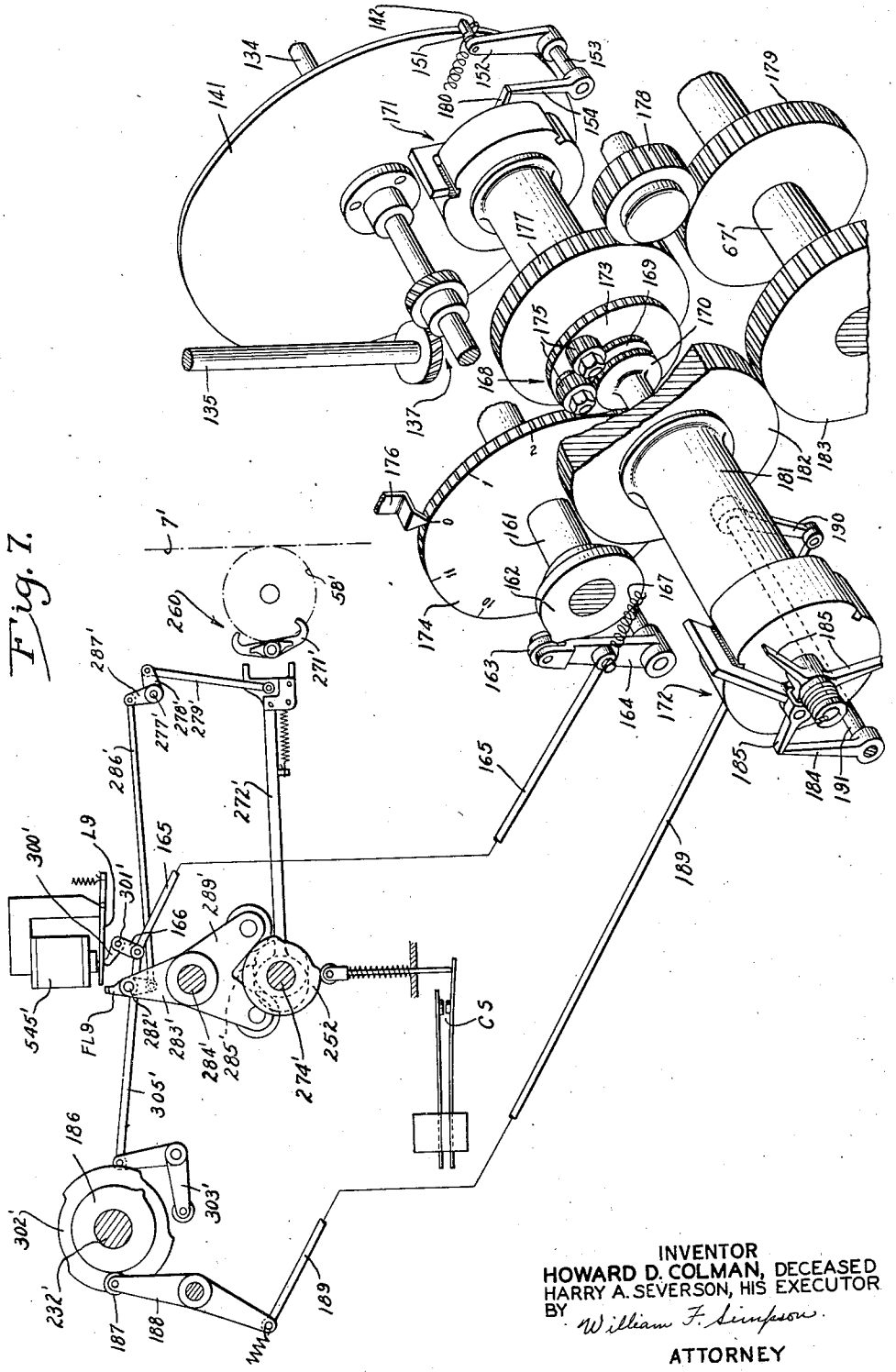
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Fig. 7.



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Fig. 8.

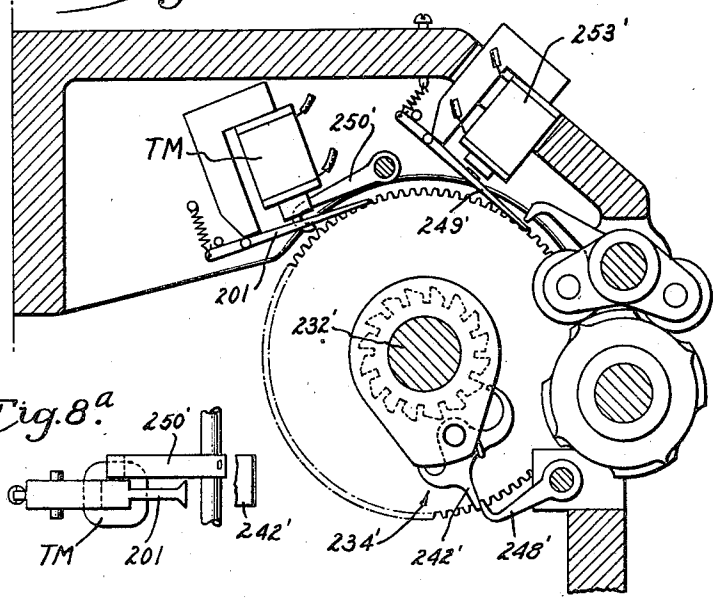
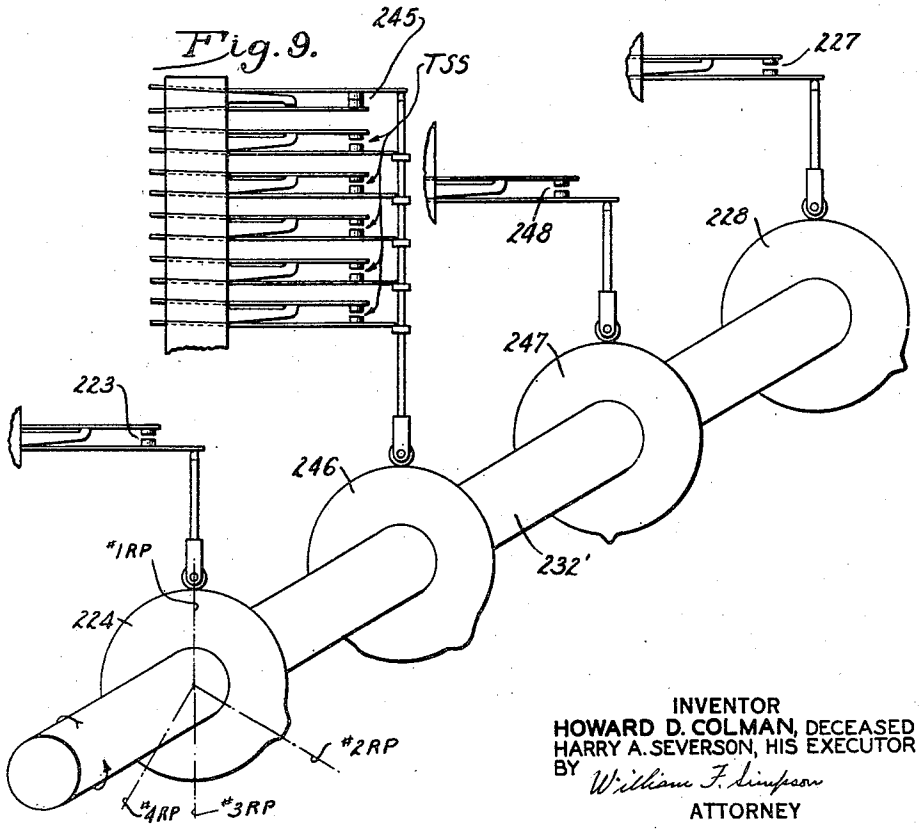


Fig. 8a.

Fig. 9.

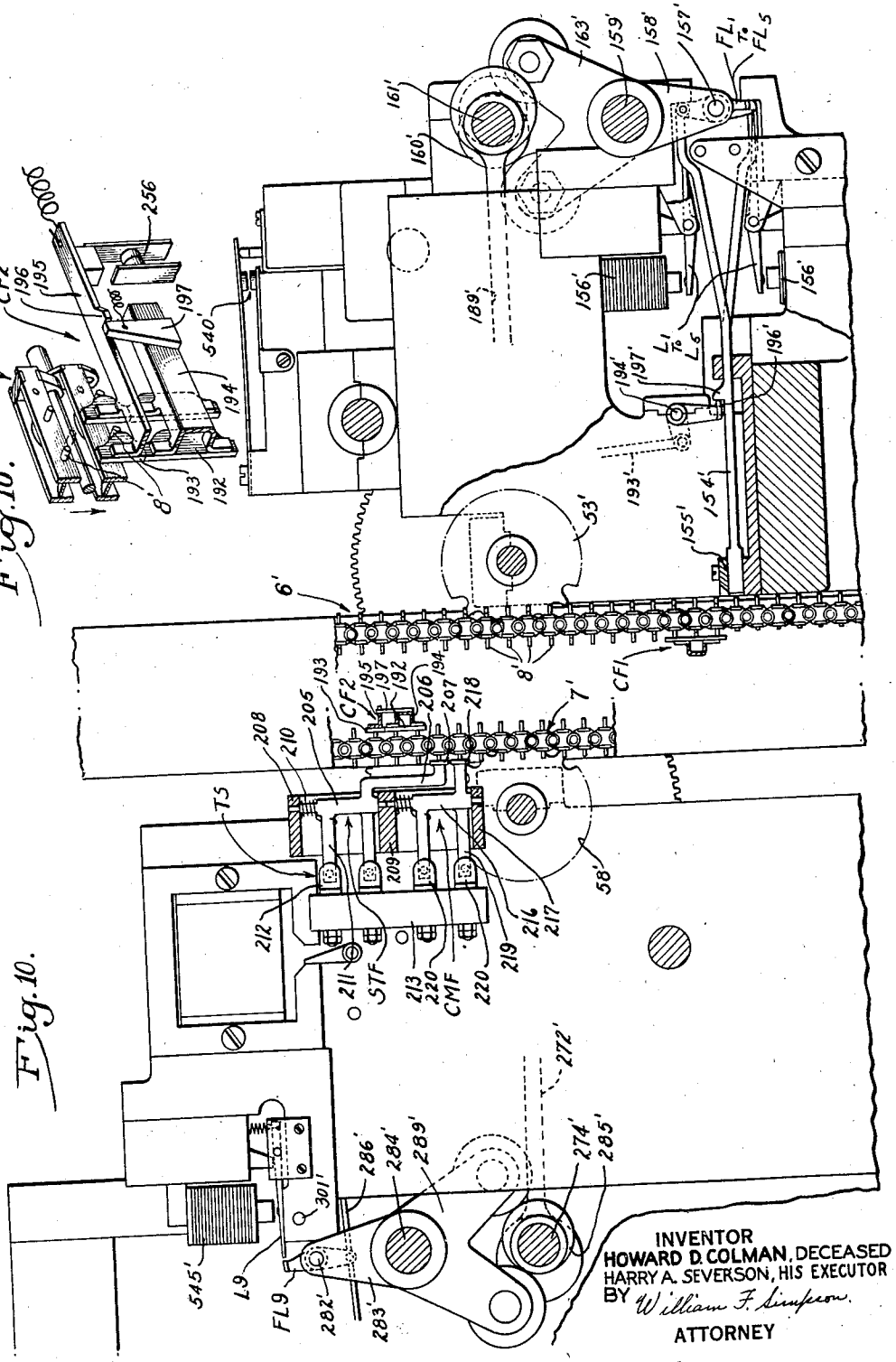


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Fig. 12.

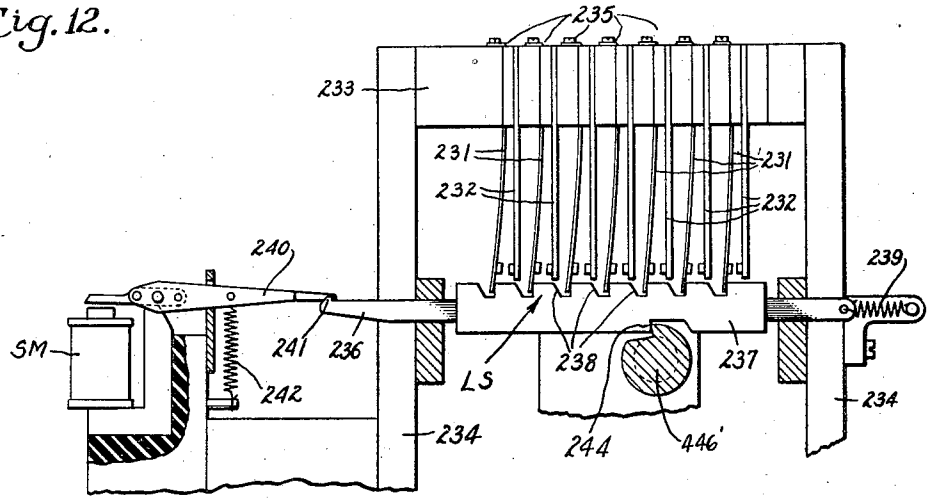


Fig. 11.

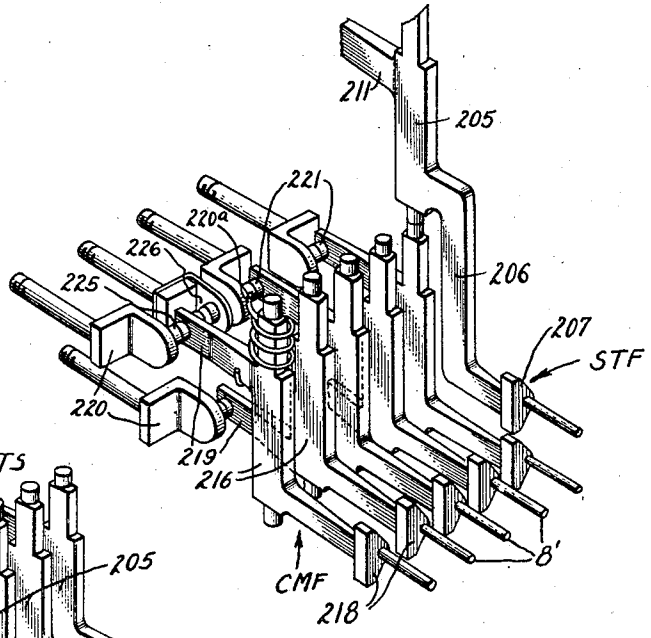
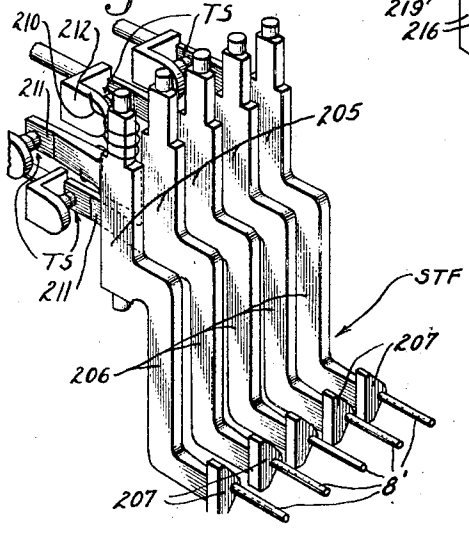


Fig. 11a.



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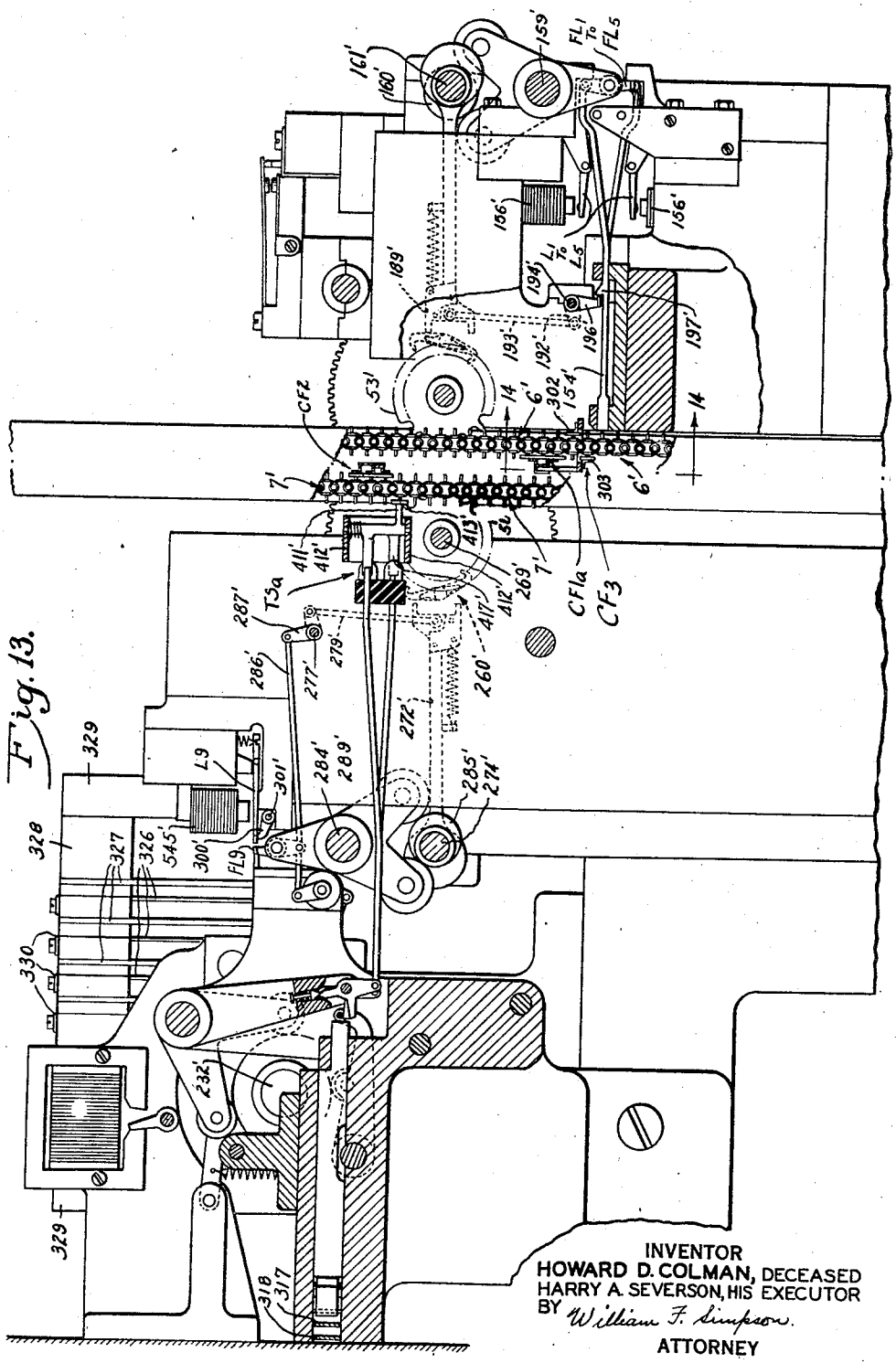


Fig. 13.

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Fig. 14.

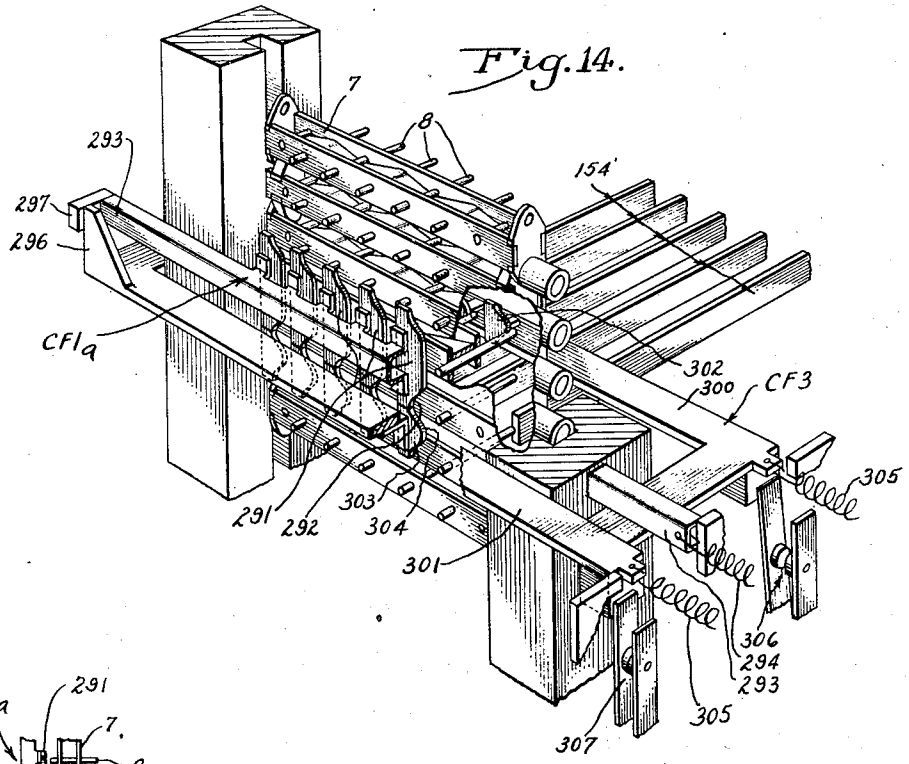
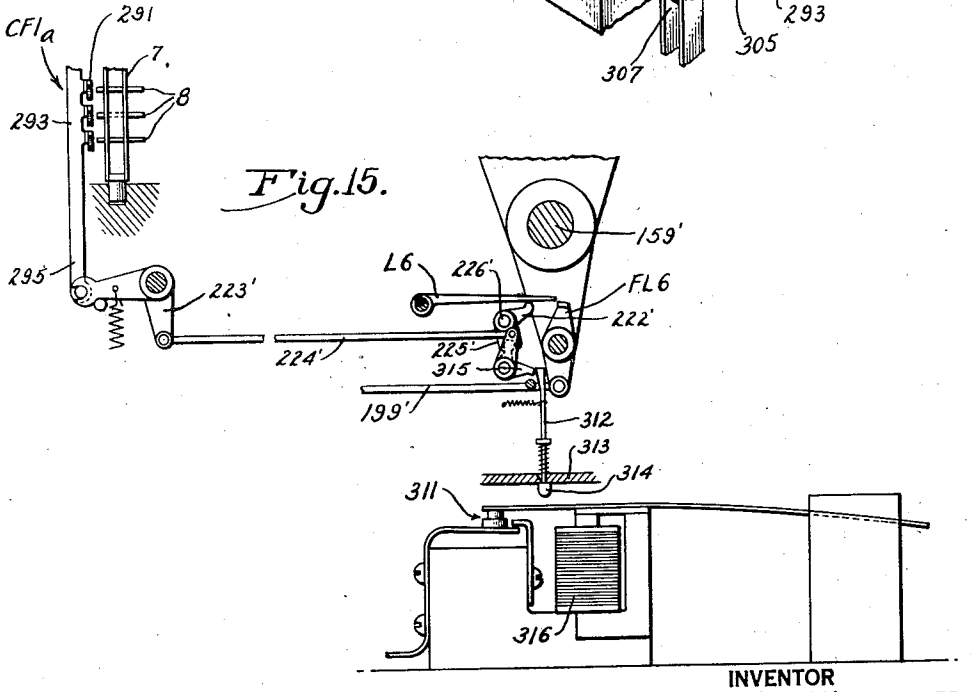


Fig. 15.



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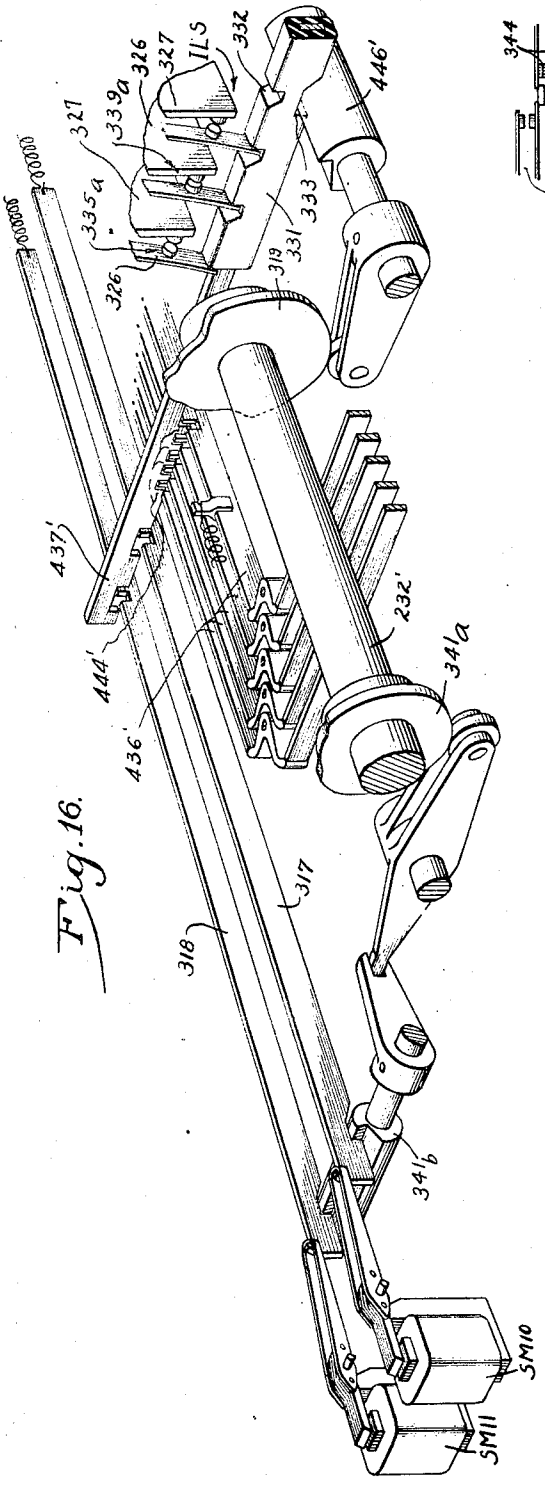


Fig. 16.

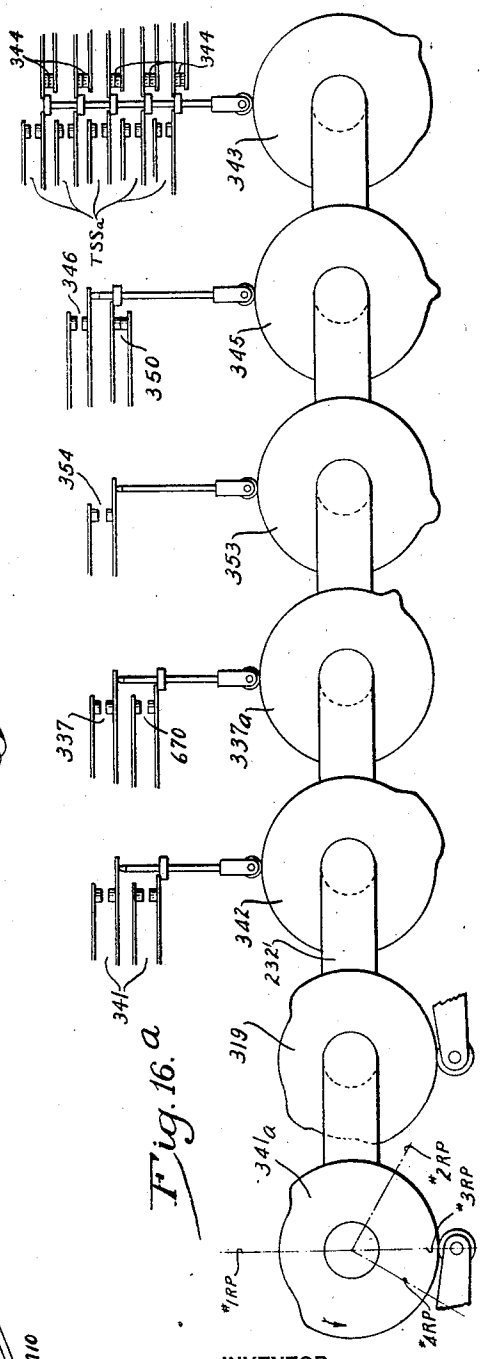


Fig. 16a

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Fig. 17.

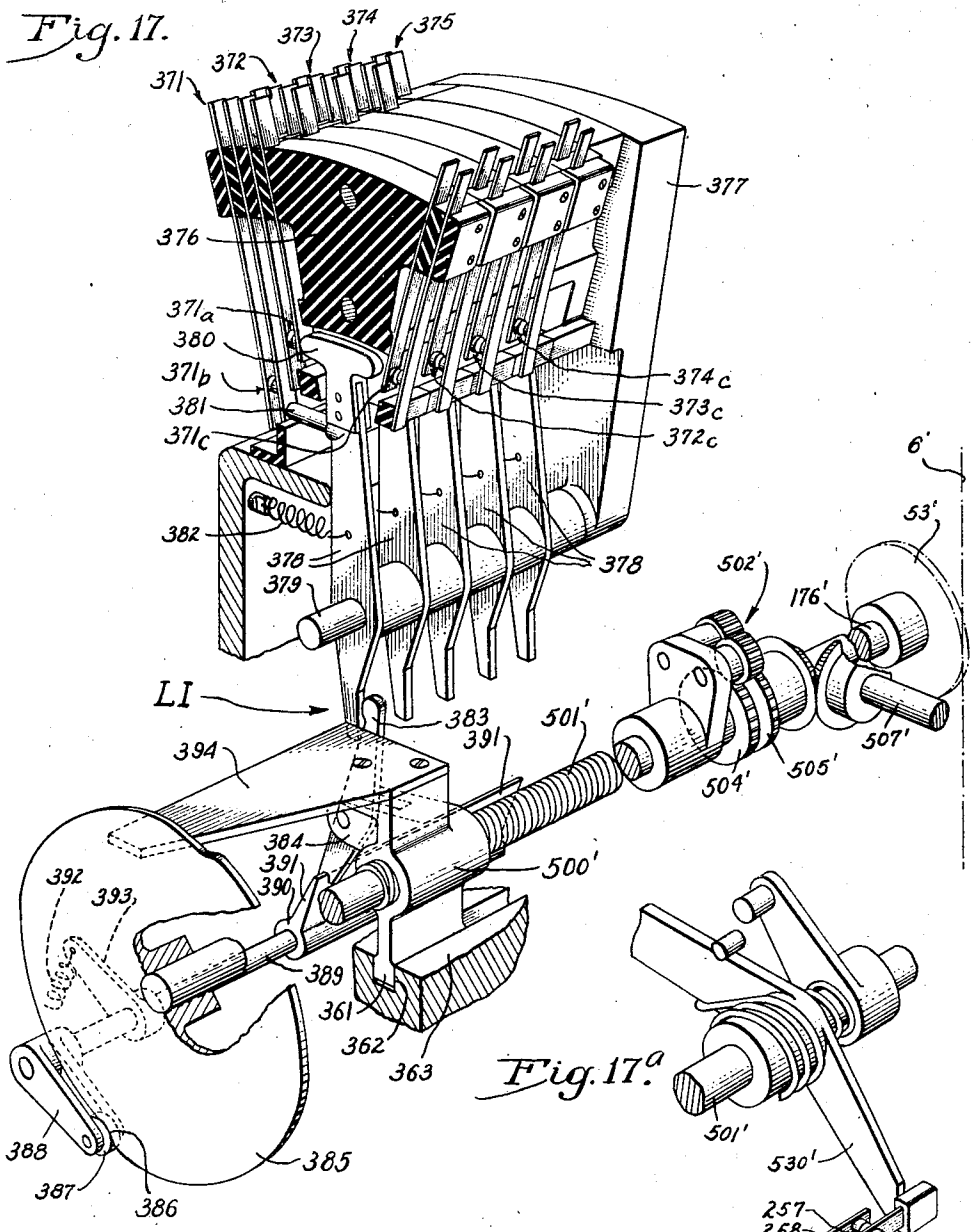


Fig. 17a.

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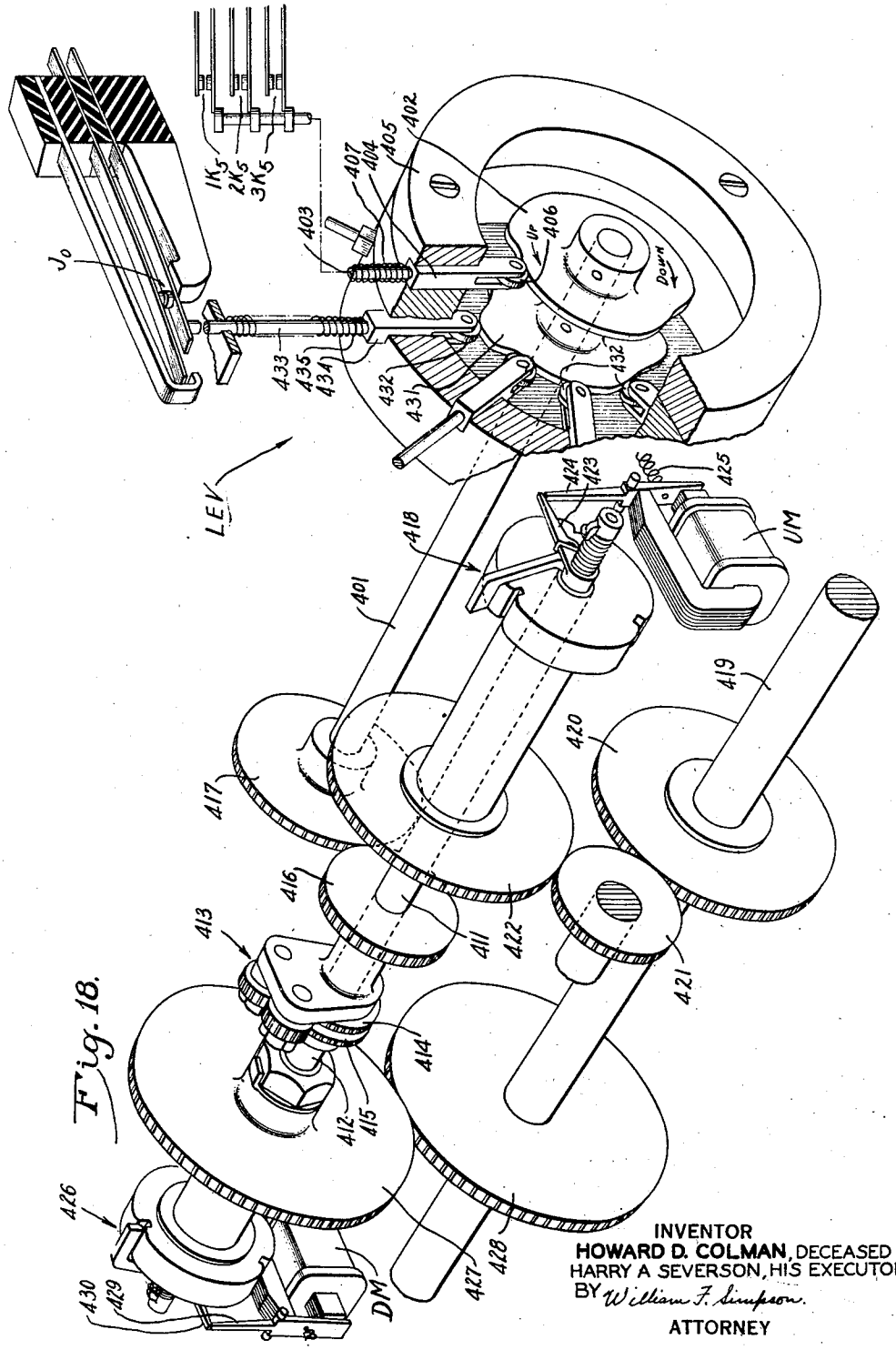


Fig. 18.

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Fig. 19.

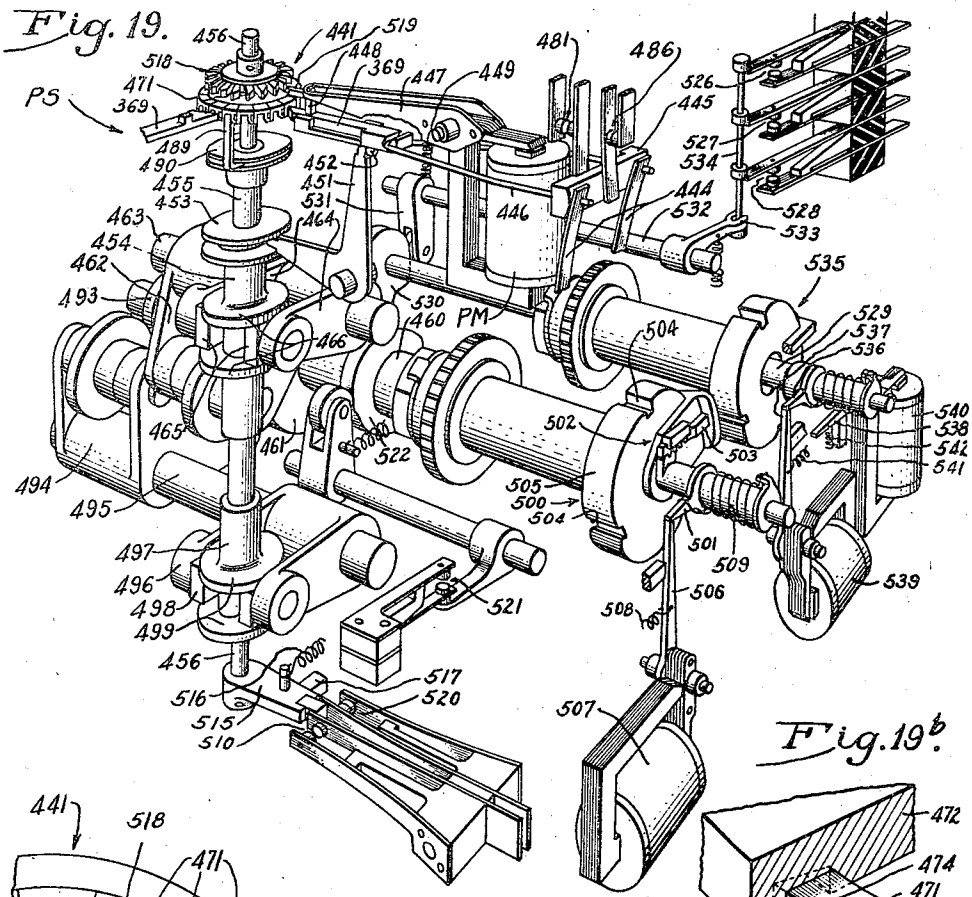


Fig. 19a.

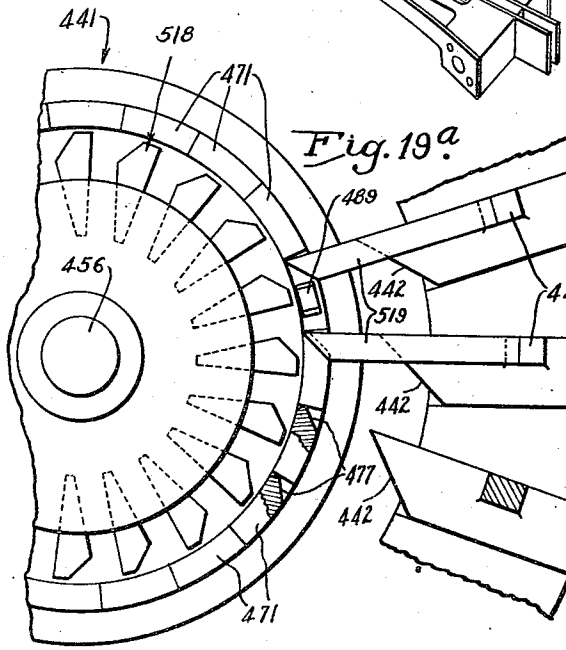
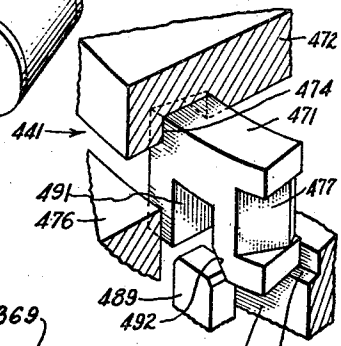


Fig. 19b.



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Fig. 20.a

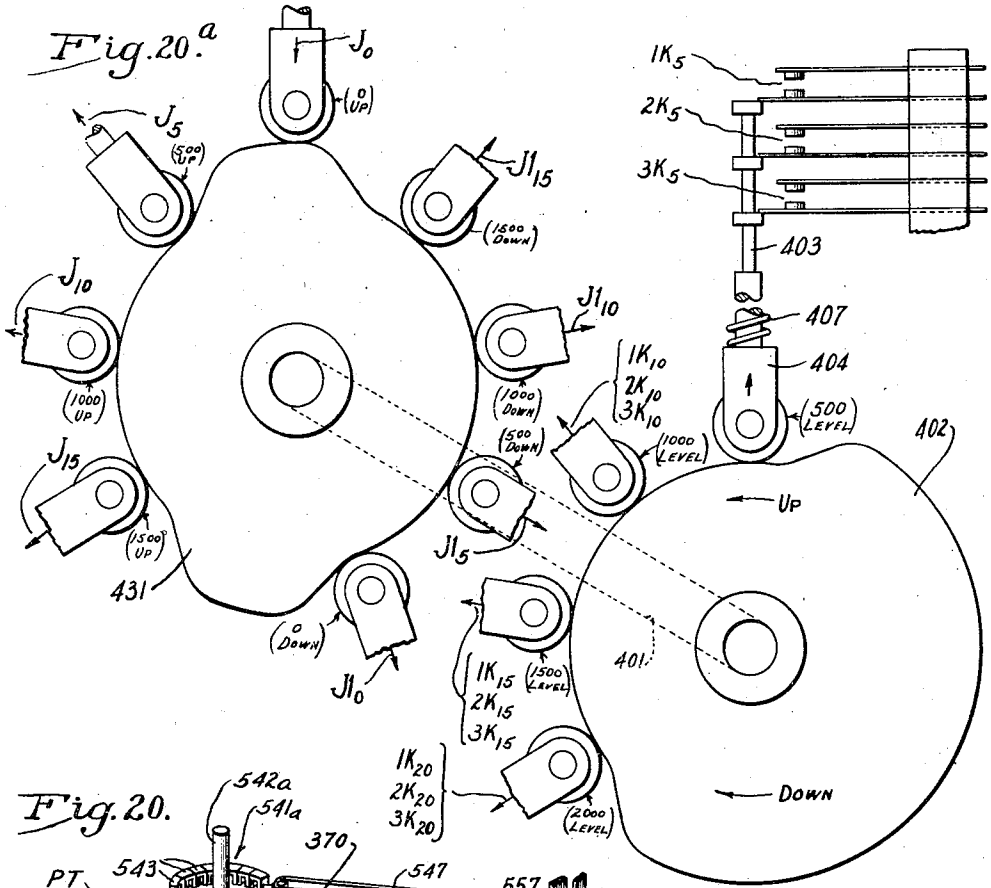
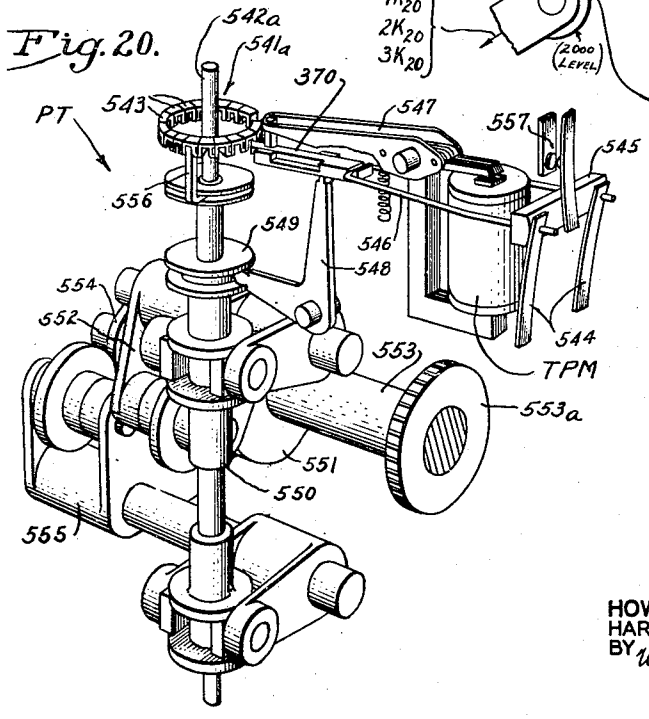


Fig. 20.



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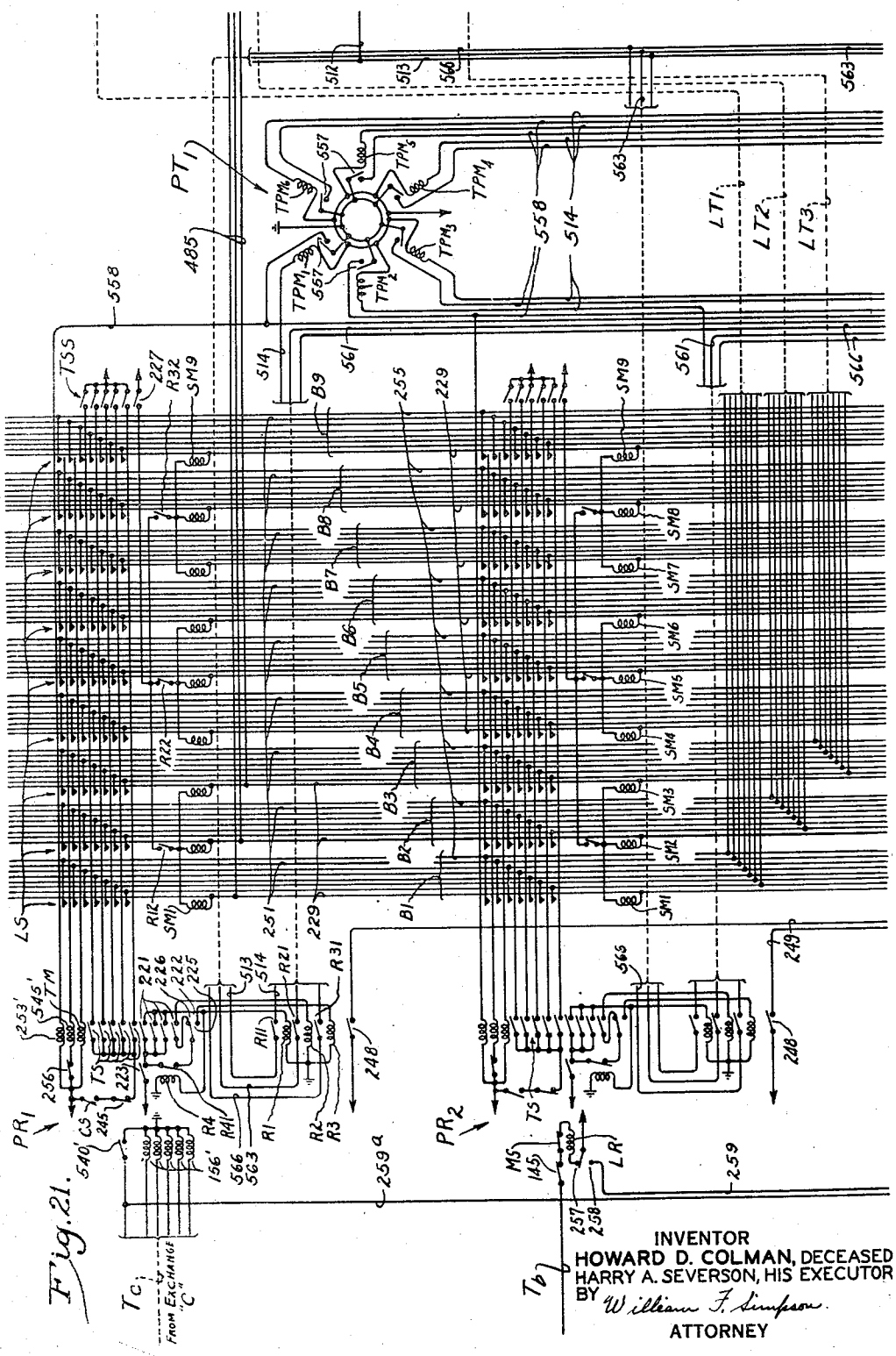


Fig. 21.

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MESSAGE INTERCEPTING AND RELAYING CIRCUITS IN AN AUTOMATICALLY DIRECTED MESSAGE TELEGRAPH SYSTEM

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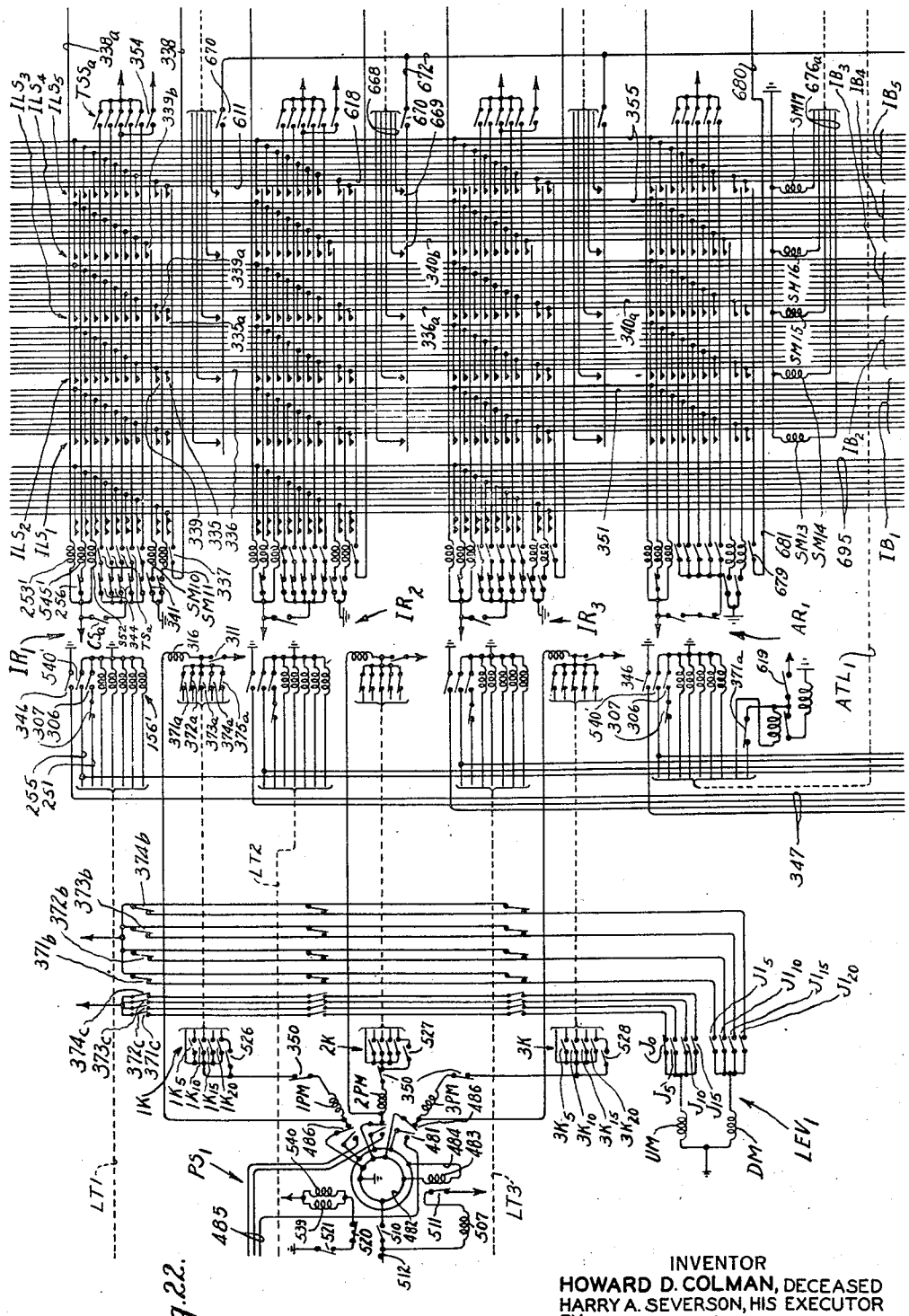


Fig. 22.

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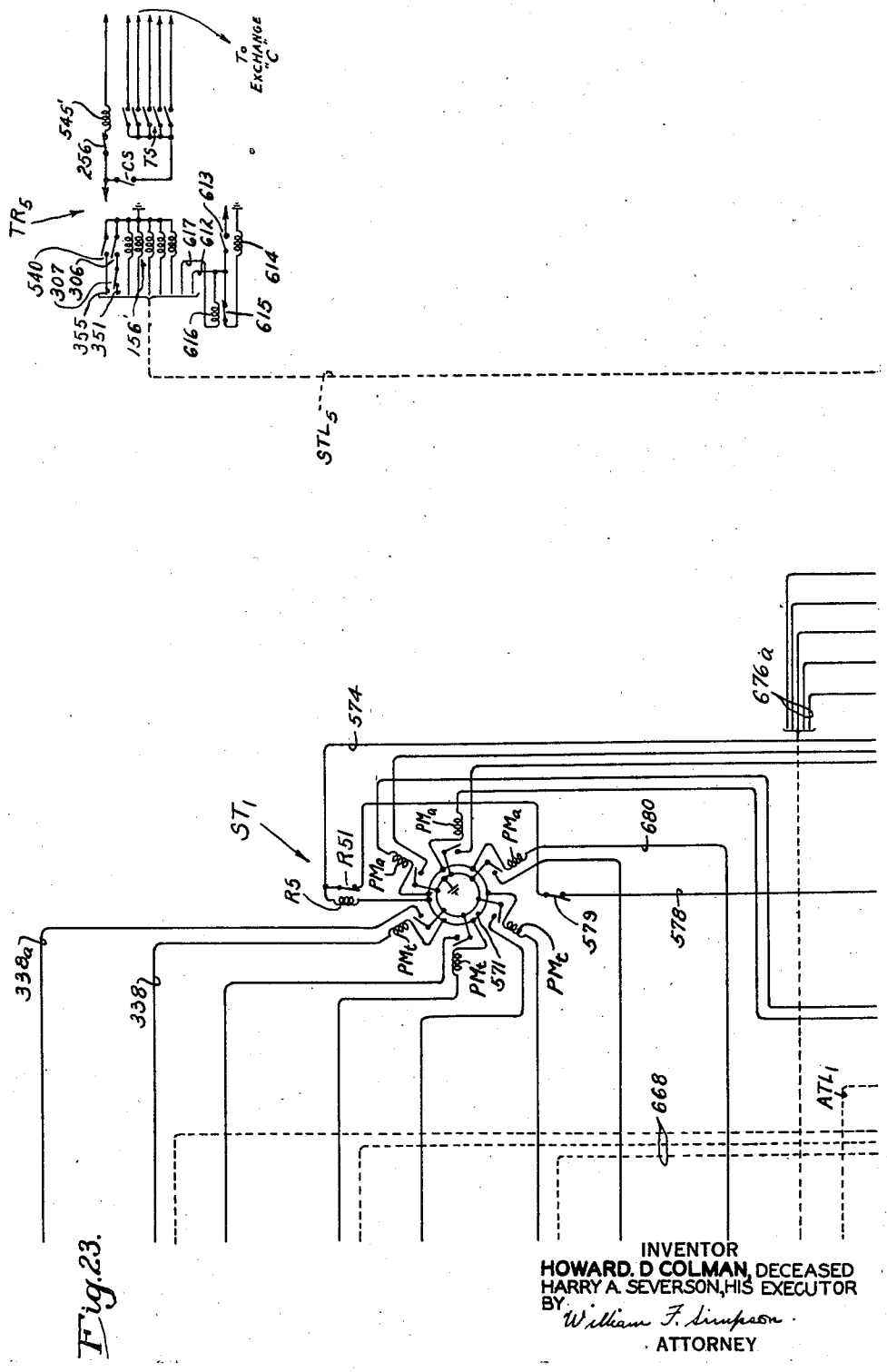


Fig. 23.

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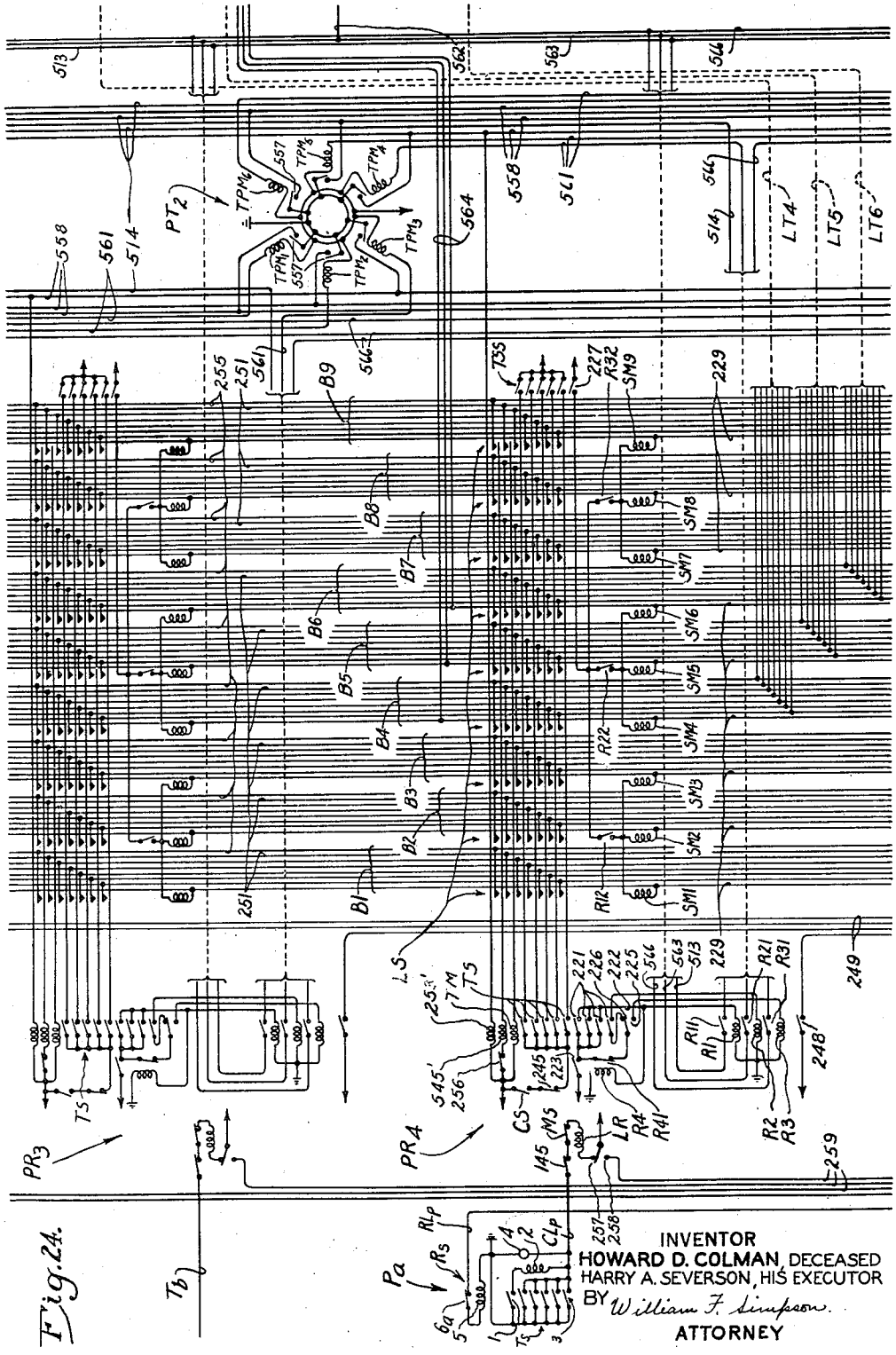


Fig. 24.

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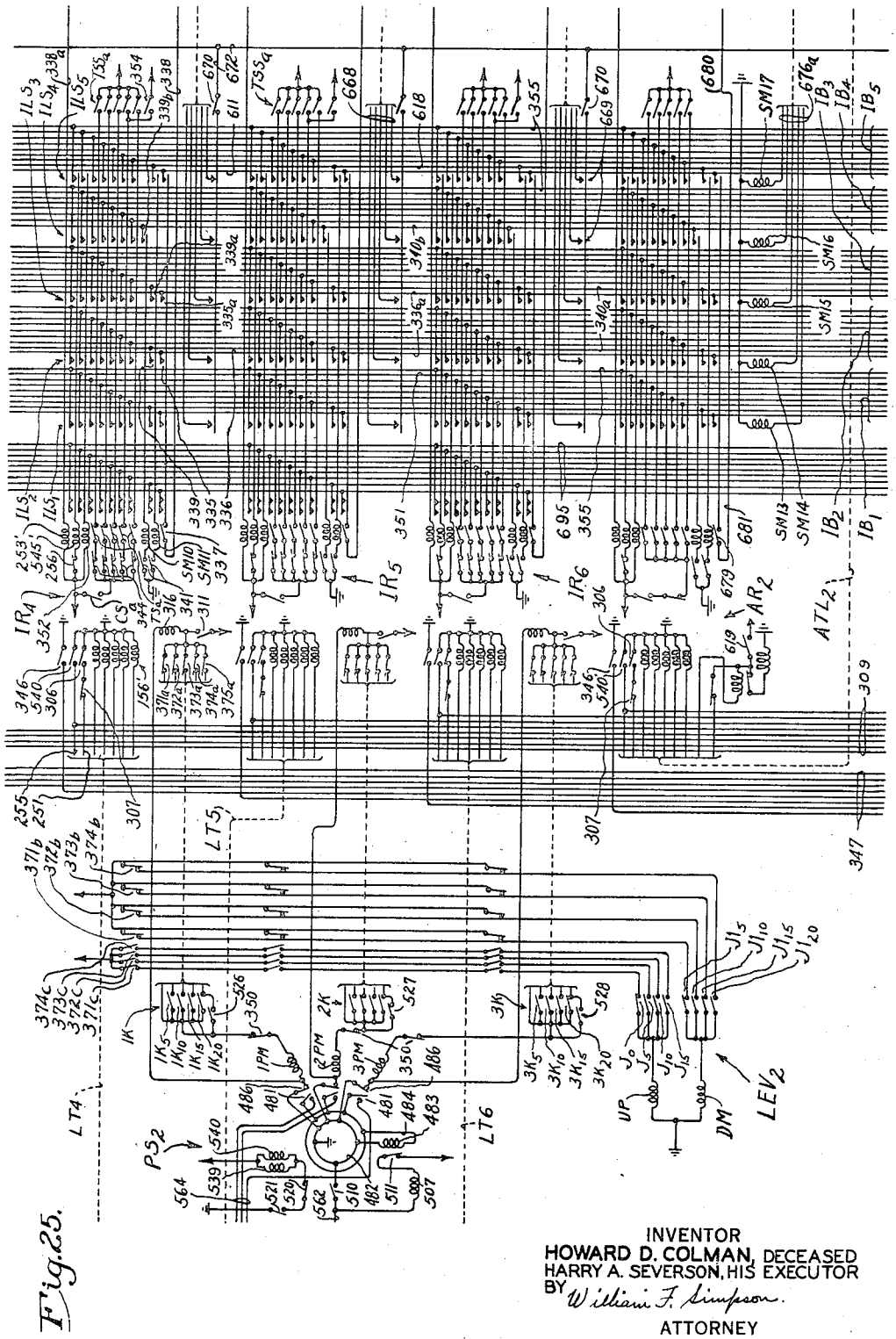


Fig.25.

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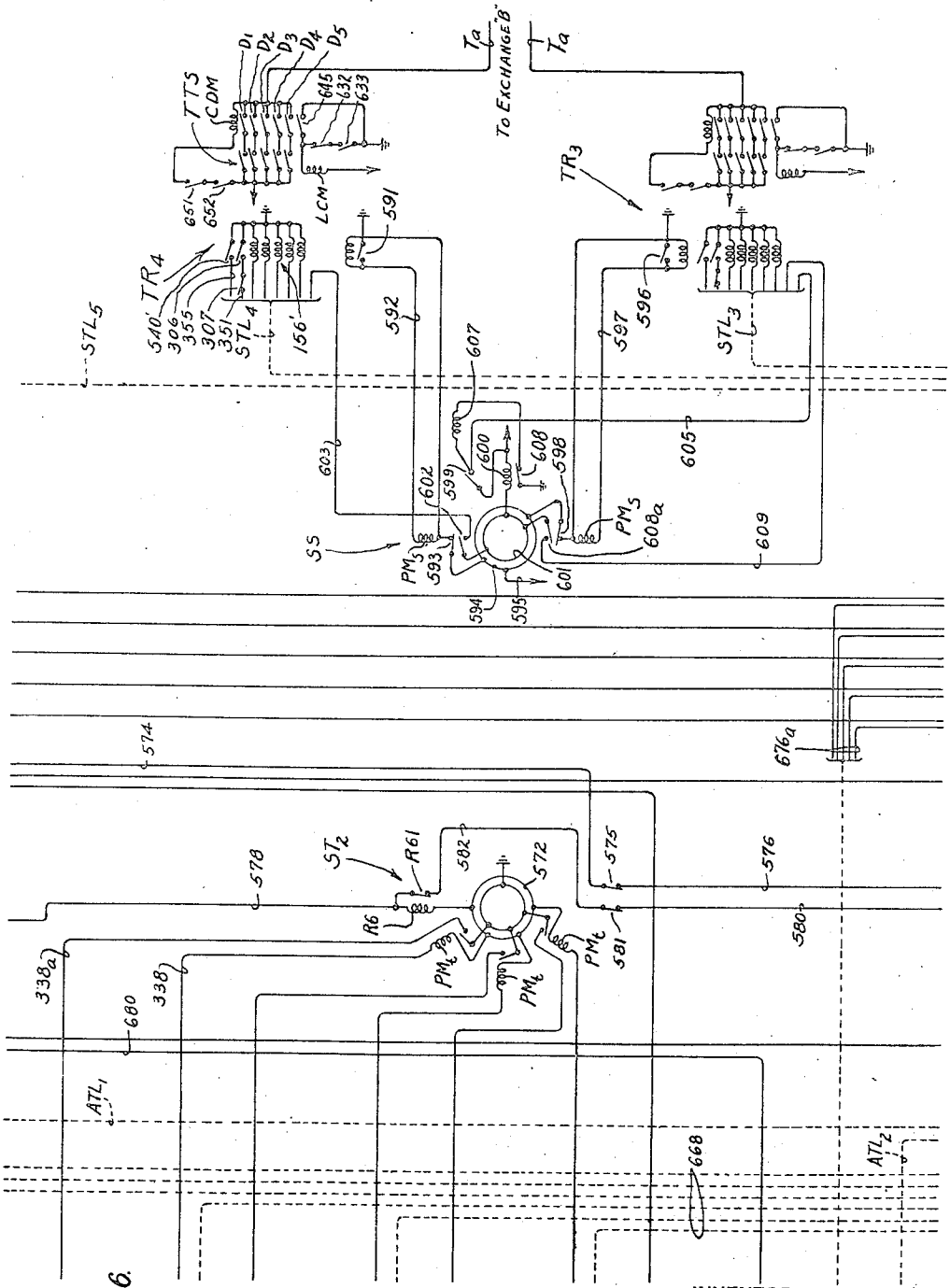


Fig. 26.

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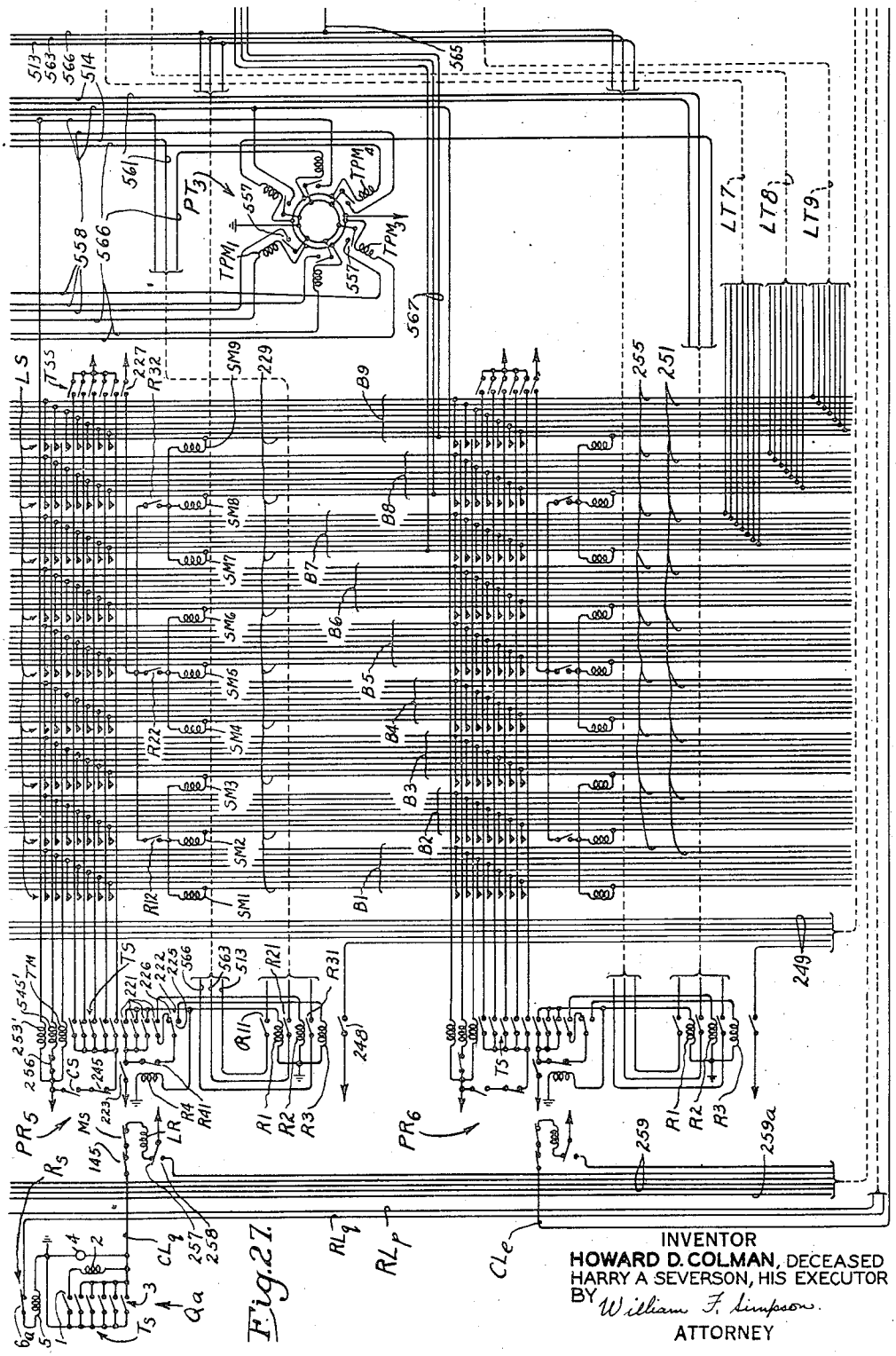


Fig. 27.

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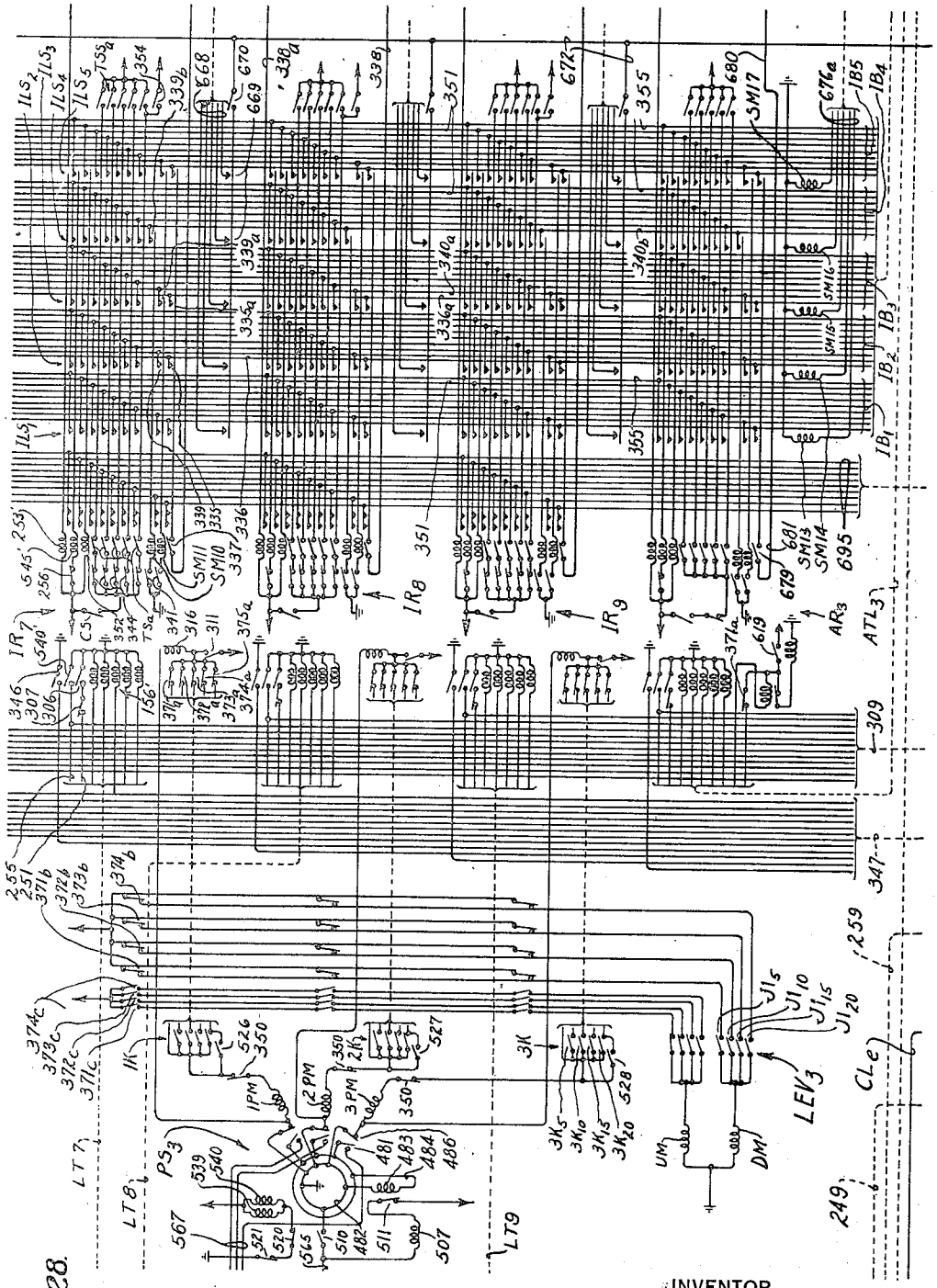


Fig. 28.

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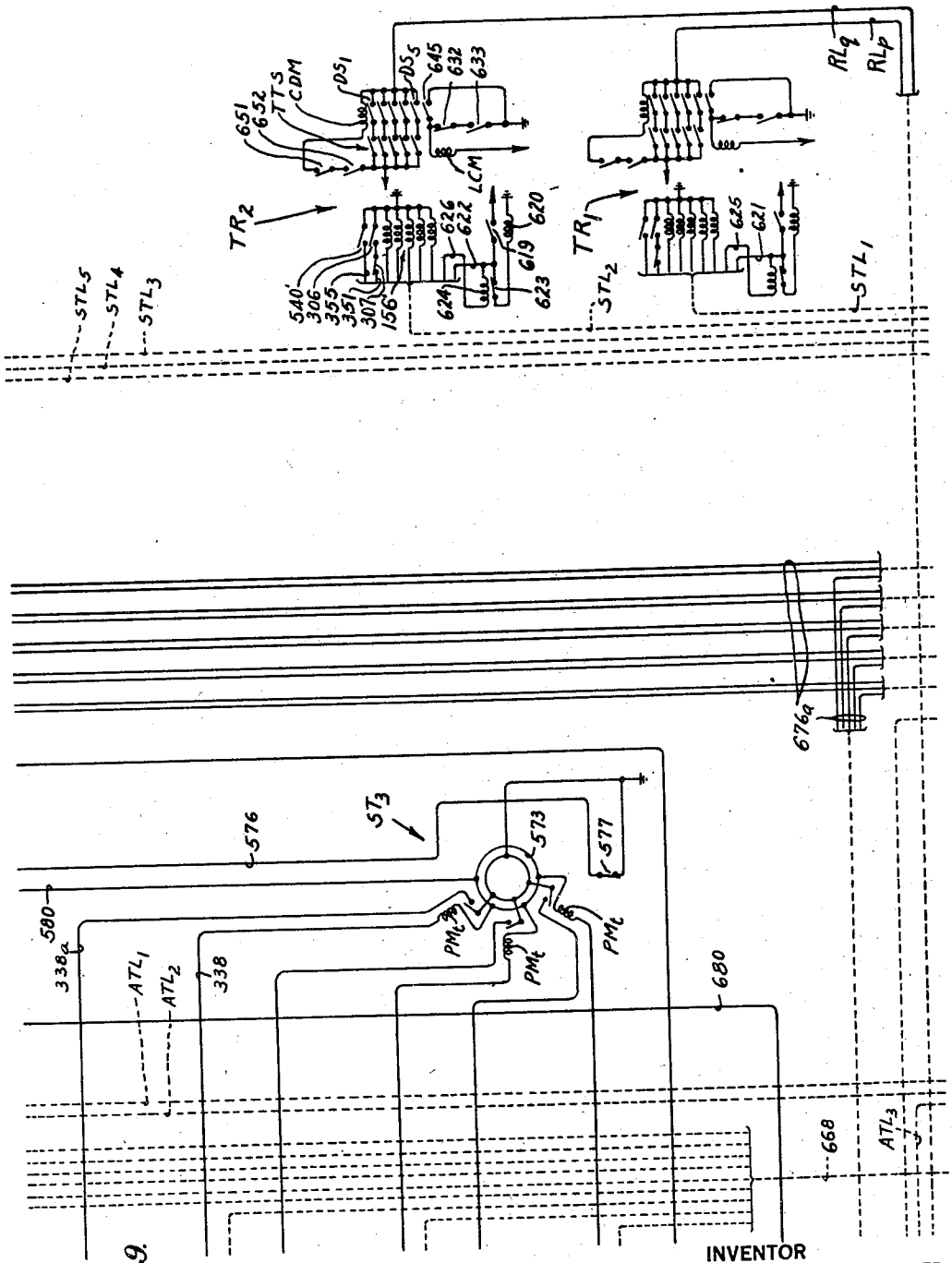


Fig. 29.

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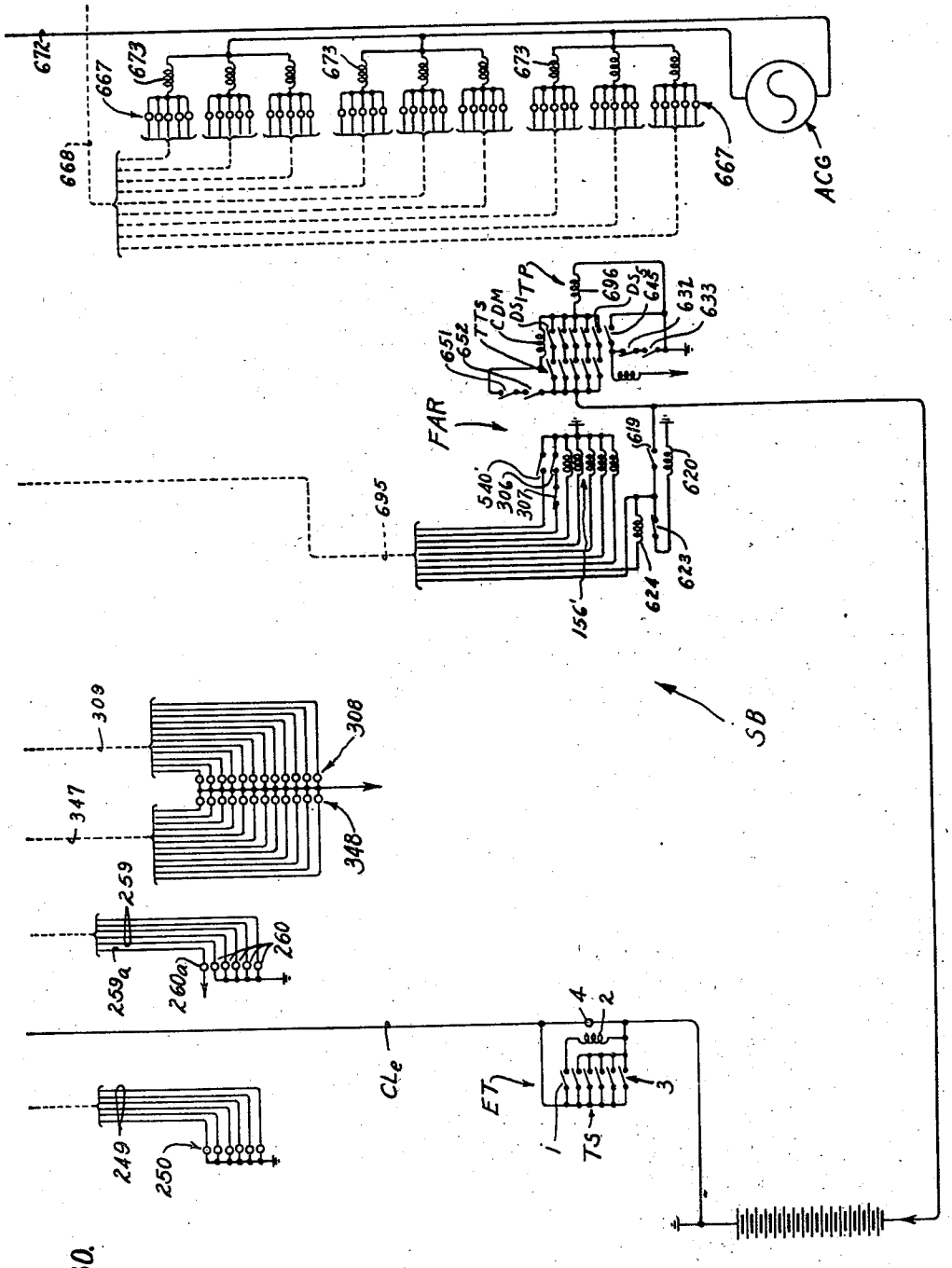


Fig. 30.

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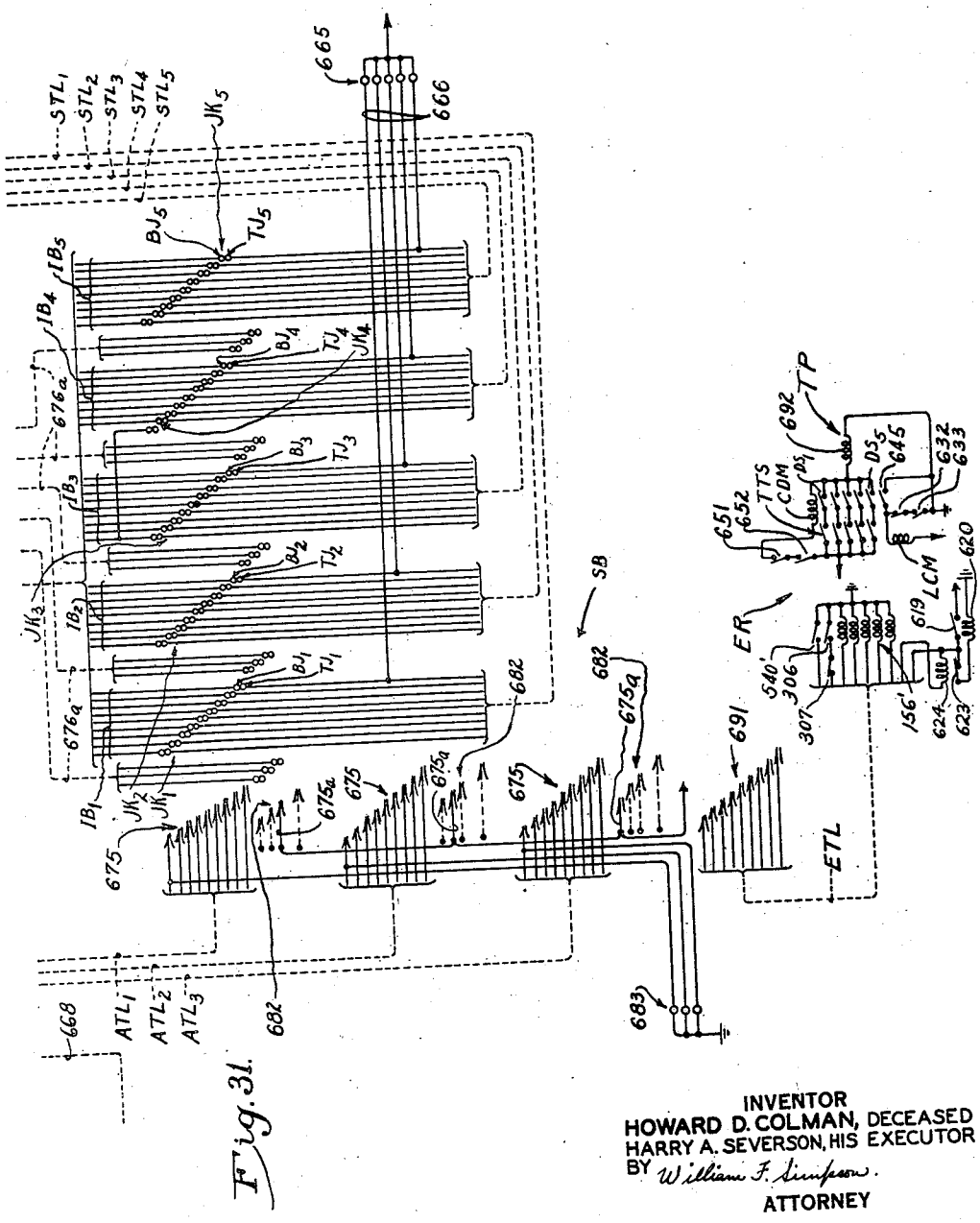


Fig. 31.

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Fig. 33.

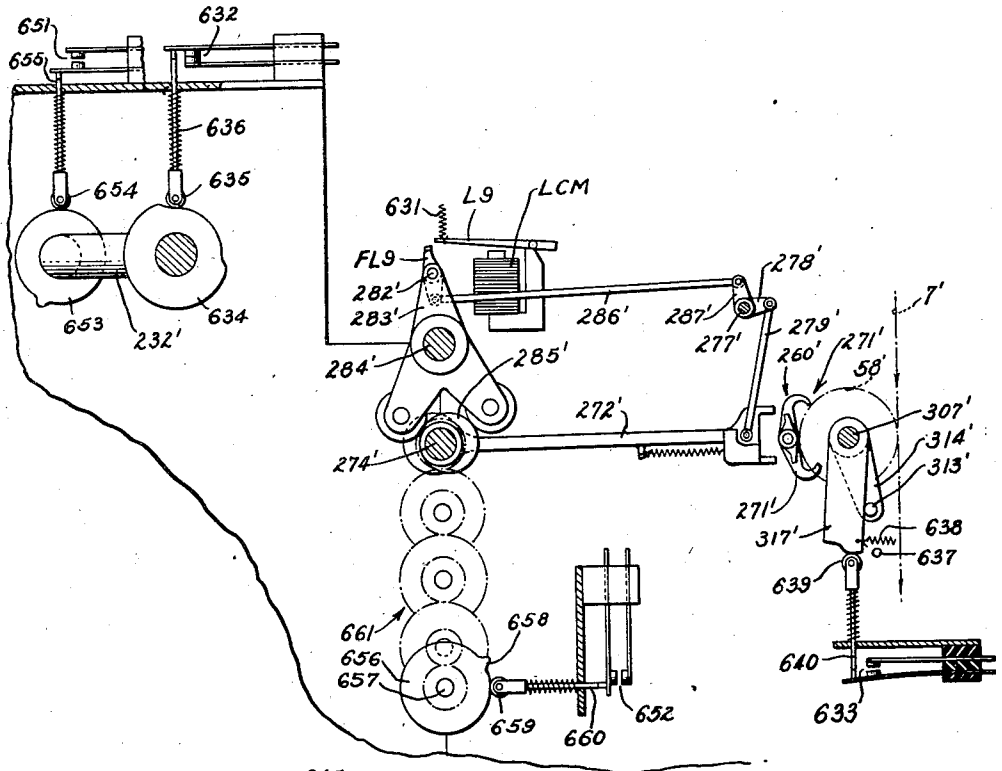
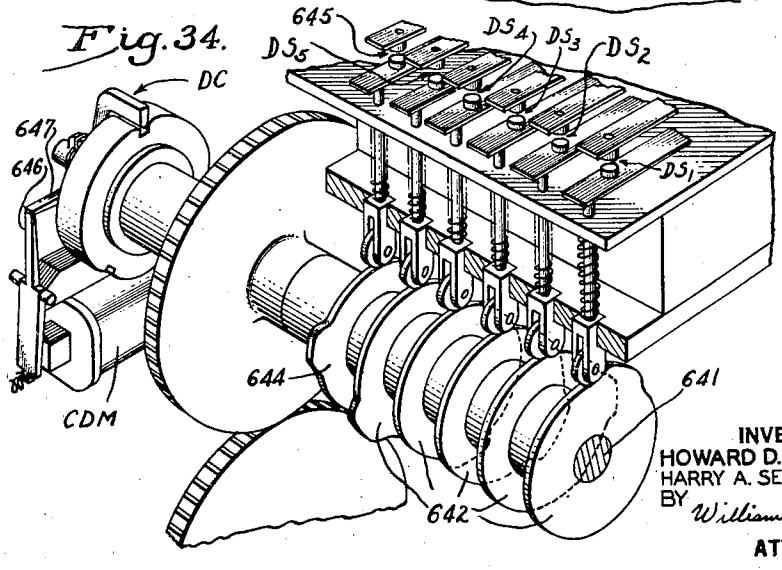


Fig. 34.



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Patented July 22, 1947 2,424,223

UNITED STATES PATENT OFFICE

2,424,223

MESSAGE INTERCEPTING AND RELAYING CIRCUITS IN AN AUTOMATICALLY DIRECTED MESSAGE TELEGRAPH SYSTEM

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The invention relates to telegraph systems in which messages are transmitted in successive steps or stages with automatic line selection, and more particularly to systems in which the individual customers or subscribers are provided with sending and receiving apparatus for the transmission and reception of messages.

The subject-matter claimed herein is divided from application Serial No. 346,285, filed July 19, 1940.

In systems of the above general character, each subscriber's station is connected by suitable line wires with a central switching point commonly called a "central office" or "exchange" at which the necessary switching operations are performed to direct messages from the calling station to the called station. The system may, of course, include more than one exchange, and in such cases the exchanges are interconnected by means of trunk lines for handling the traffic between subscribers whose lines terminate at different exchanges.

A system particularly suitable for automatic transmission within and between telegraph exchanges in disclosed in applicant's copending application Serial No. 319,047 (filed November 13, 1928), now Patent No. 2,380,394, granted July 31, 1945. In that system, the messages are transmitted through a plurality of stages under control of a portion of the message and thence directed to an outgoing line. In an improved form of automatic storage and switching system disclosed in application Serial No. 346,285, supra, there are disclosed further developments and improvements over the methods and apparatus disclosed in the said prior application to the end that the range of automatic operation is extended so as to embrace subscribers' stations and lines which are provided with extensively employed commercial types of equipment, i. e., start-stop equipment, to the end that messages may be relayed from their points of initial origin directly to their final destinations of transmission at such subscribers' stations without the intervention of an attendant.

In said application Serial No. 346,285 there is disclosed an exchange system at which terminate incoming lines and trunks and outgoing lines and trunks and which includes one or more sending units local to the exchange each connected to input storage devices of the exchange in the fashion of a line incoming thereto. Incoming messages may arrive over high speed simultaneous transmission trunks or lower speed subscriber lines operated start-stop. Each message upon initial

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reception is stored in a primary storage unit or storage device individual to an incoming line and upon the receipt of an end-of-message signal it is transferred to a secondary storage unit at high speed by a five-wire trunk. It is therefore contemplated that no message exceed the storage capacity of a primary storage unit; obviously longer messages can be separated into sections in which each section is handled as a message by the mechanism. Intermediate storage units may be of several classes for preferred, ordinary and deferred messages and each message may be directed to a secondary storage device characteristic of its class under control of a class-of-message designation incorporated with the message along with the address thereof. From the secondary or intermediate storage devices messages are transferred automatically and selectively according to their respective address signals under control of the address signals to outgoing or final storage devices; preferred messages are automatically given preference in such transfer over all others, and ordinary messages are given preference over deferred messages.

For various reasons it may be desirable to withdraw a message from a storage device into a special storage device such as an auxiliary or emergency storage unit and features of apparatus and equipment, as well as methods of operation, for accomplishing this result are shown herein.

For this purpose there are disclosed and described herein auxiliary relay units, emergency relay units and false address interceptor units.

The fundamental object of the invention in respect to the auxiliary relay units is to remove a message from storage when for some reason, for example, a trouble condition, it is blocking messages stored behind it which could, except for the blocked message, proceed toward their destinations; this object is achieved by providing arrangements to remove messages, one at a time, from blocked units to auxiliary units, thus allowing other messages directed to other destinations to proceed, after which the removed messages stored in the auxiliary units may be further transmitted, assuming that the trouble which blocked them has been cured.

With respect to the emergency units, the object is to remove messages from a storage unit for a time which may be long or short for the purpose of recording it at the central office and then, if desired, retransmitting it; this object is fulfilled by the provision of a suitable emergency storing unit associated with printing means which typifies any suitable recording means and means for di-

recting messages thereto by the office attendant.

Messages supplied with addresses which do not exist or address codes directing them to channels which are unequipped are likely to be sources of delay and become blocked messages; such difficulties are prevented by automatically routing them to a false address storage unit. Any one of these unassigned addresses may be used for intentional delivery to and recording of messages at the central office.

A general object of the present invention is to provide an improved automatic telegraph system utilizing novel methods of and apparatus for receiving, storing and retransmitting telegraph messages whereby the apparatus and line equipment of the system may be operated at maximum efficiency.

Still another object is to provide a novel method of and apparatus for supervising the traffic movement through an automatic telegraph exchange.

Other objects and advantages of the invention will become apparent from the following detailed description of the exemplary embodiment illustrated in the accompanying drawings, in which:

Figs. 1 and 2 are layout diagrams of two exchanges of a multiexchange telegraph system embodying the features of the invention;

Fig. 3 is a diagrammatic view of the signal storage mechanism interposed between the recorder and transmitter of each relay unit;

Fig. 4 is a perspective view of the start-stop recorder of a relay unit;

Fig. 5 is a fragmentary vertical sectional view of the recorder shown in Fig. 4;

Fig. 6 is a detail view of the recorder line relay and control elements associated therewith;

Fig. 7 is a perspective view of the message counting mechanism;

Fig. 8 is a sectional view of the principal transmitting cam shaft and the clutch controlling detents for stopping the shaft in different rest positions as employed in the various relay units;

Fig. 8[a] is a detail view showing the arrangement of the clutch detents at the No. 3 and No. 4 rest positions;

Fig. 9 is a fragmentary perspective view of the transmitting cam shaft and various switches actuated thereby;

Fig. 10 is a vertical sectional view of a primary relay unit equipped with a recorder arranged for simultaneous reception;

Fig. 10[a] is a perspective view of the end-of-message feeler mechanism;

Fig. 11 is a perspective view of the class-of-message feelers of the primary relay unit transmitter;

Fig. 11[a] is a perspective view of the signal transmitting feelers;

Fig. 12 is a view showing one of the line switches for selectively connecting a trunk line to the transmitter of a primary unit;

Fig. 13 is a vertical sectional view showing the general arrangement of the parts of an intermediate relay unit;

Fig. 14 is a perspective view of the test signal checking feeler;

Fig. 15 is a fragmentary view partly in plan and partly in elevation showing the mechanism for indicating the availability or non-availability of an intermediate relay unit;

Fig. 16 is a perspective view of a permutational line selector showing one of the switches controlled thereby;

Fig. 16[a] is a partial perspective view of an intermediate relay unit transmitting cam shaft;

Fig. 17 is a perspective view showing a part of the loop indicator and the level switch mechanism of an intermediate relay unit;

Fig. 17[a] is a partial perspective view of the full storage stop control means;

Fig. 18 is a perspective view of the level switcher;

Fig. 19 is a perspective view of a primary solicitor and associated level shunt mechanism;

Fig. 19[a] is a horizontal sectional view showing details of the plunger selecting mechanism of the solicitor;

Fig. 19[b] is a detail view of one of the circulating blocks forming a part of the plunger selecting mechanism;

Fig. 20 is a perspective view of the primary time assigner;

Fig. 20[a] is a diagrammatic view showing the switches and switch operating cams of the level switcher;

Figs. 21 to 31, inclusive, are circuit diagrams showing the electrical circuit arrangement of different parts of the exchange shown diagrammatically in Fig. 1;

Fig. 32 is a diagram showing the manner in which Figs. 21 to 31, inclusive, should be arranged to illustrate the relationship of the various equipment units and the electrical circuits of a complete exchange constructed in accordance with the invention;

Fig. 33 is a diagrammatic view showing parts of the start-stop transmitter of a terminal relay unit; and

Fig. 34 is a perspective view of the distributor as employed in the terminal relay units.

The system in general

In the improved telegraph system contemplated by the invention, each subscriber's station is equipped with telegraph transmitting and receiving apparatus for sending and receiving messages electrically in the form of code signals. In sending a message the subscriber incorporates in it one or more directing signals including an order of preference portion or class-of-message signal, an address portion consisting of one or more signals indicating the destination of the message, and an end-of-message signal.

The directing signals and those representing the body of the message are recorded at the exchange, and the latter are relayed automatically through one or more switching stages to the destination point under control of the directing signals. While any suitable means may be employed for relaying the messages, it is preferred to utilize equipment capable not only of receiving and transmitting, but also of temporarily storing one or more messages in mechanical form.

In the exemplary form herein shown, the equipment for relaying the messages comprises an assembly of relay units, each including a signal receiving mechanism or recorder, a signal storage mechanism including a mechanical storage medium, and a signal transmitter. These units are all driven in exact synchronism as by synchronous electric motors operating from a common source of power. While the relay units are all of similar construction, their recorders and transmitters are arranged to receive and transmit signals according to the system of transmission best suited to the conditions under which the units are required to operate. Thus, there is provided a basic equipment organization which can be

adapted for operation under a variety of conditions by relatively simple changes in the individual components of the same. This standardization of equipment reduces manufacturing costs and facilitates maintenance of the equipment.

In the exchange the units are arranged in successive ranks or switching stages suitably interconnected by local trunk lines so that messages can be transferred step by step from one rank of units to the next, each unit advancing the message toward its destination. The transfer of messages is effected under control of novel traffic distributing mechanisms arranged to prevent two units of one rank from simultaneously seizing the same unit of the next rank or one of the first-mentioned units from seizing two of the latter units and for keeping the traffic uniformly distributed over the various units.

The general arrangement of the relay units and the manner in which they function in relaying messages from a calling subscriber to a called subscriber may be readily seen by reference to the exemplary telegraph system of which the trunking layout of two exchanges A and B is shown diagrammatically in Figs. 1 and 2 when these figures are placed end to end with Fig. 2 at the right. It will be understood, of course, that the system may consist of any desired number of exchanges.

Referring to Figs. 1 and 2, the exchanges shown by way of illustration are generally similar, each having three switching stages or three ranks of relay units. The relay units of the first rank hereinafter called "primary relay units" and designated generally by the reference character PR with the suffixes 1 to 5, inclusive, are adapted to receive and store messages transmitted to the exchange over subscribers' calling lines and incoming trunk lines from other exchanges of the system. Thus certain of the primary units, in this instance the units PR_4 and PR_5 terminate calling lines CL_p and CL_q from subscribers stations P and Q. For convenience of identification the subscribers' stations are further distinguished by the suffix *a* or *b* to designate the exchange in which the lines terminate. Other of the primary units PR terminate incoming trunk lines T_a, T_b, T_c and T_d from other exchanges of the system.

The second or intermediate rank of units designated generally by the reference character IR with suffixes 1 to 9, inclusive, and conveniently called "intermediate relay units" constitutes a storage reservoir for all incoming messages received by the primary units, the messages being transferred to the intermediate units selectively under control of signals incorporated herein. As herein shown, the intermediate units are divided into three groups for handling messages of different classes. The class-of-message signal incorporated in the message determines the particular group of intermediate units to receive the message, thus first-class messages are automatically routed to the units IR_1, IR_2 or IR_3 constituting group No. 1, ordinary messages are routed to units IR_4, IR_5 or IR_6 constituting group No. 2, and third-class messages are routed to units IR_7, IR_8 or IR_9 constituting group No. 3.

Messages stored in the intermediate relay unit groups are transferred selectively in the order of their preference to "terminal units." These units are designated generally by the reference character TR with suffixes 1 to 5, inclusive, and constitute the third rank of relay units. Thus, messages stored in group No. 1 have preference over messages stored in the other groups or more particularly, any unit of the latter group seeking a transmitting channel coincidentally with a unit of the preferred group must wait until the unit of the preferred group has obtained its channel. Similarly, messages stored in group No. 2 are given preference over messages stored in group No. 3. The transfer of the messages from the intermediate units to the terminal units is effected selectively under control of the address signal or signals embodied in the message. The terminal units TR, in turn, relay the messages over receiving lines RL to the subscribers' stations or over trunk lines T to other exchanges in the system.

Prior to the transfer of a message from one rank of units to the next, test signals are automatically transmitted over the transmission path to determine the operativeness of the equipment involved. If the test signals are correctly received at the receiving unit, transfer of the entire message is immediately initiated. If, however, the test signals are not correctly received, the sending unit is stopped in a trouble position and a signal is operated to notify an attendant of this condition.

While start-stop or any other suitable system of transmission may be utilized in relaying messages through an exchange, the exemplary system utilizes simultaneous transmission, that is, a system of transmission in which all of the components of a signal combination are transmitted simultaneously over separate transmission paths. These paths may consist of separate conductors or separate carrier channels on a single conductor. Because of its substantially higher speed, this type of transmission materially increases the operating efficiency of the apparatus and trunking equipment and reduces the amount required to handle a given volume of traffic. It also eliminates or substantially reduces the delay or "office drag" in the passage of a message through the exchange system, thus increasing the speed of service.

Start-stop transmission is preferably employed between subscribers' stations and the exchanges since it permits of installation at the subscriber's station of apparatus which is a close approximation to conventional equipment and inexpensive, simple to operate, and of sufficiently rugged construction to be maintained in proper operating condition with a minimum of labor and expense. Moreover, this system of transmission is particularly suitable where manually operable transmitters are employed as such transmitters are inherently limited to the sending speed of the operator.

The system of transmission employed between exchanges will depend upon many different factors such as the volume of the traffic, the distance between exchanges, the line equipment available, etc. Where traffic is extremely heavy and suitable line equipment is available, simultaneous transmission is advantageous on account of its speed. Where traffic is heavy but line equipment is limited, synchronous transmission may be employed. For light traffic start-stop transmission is usually satisfactory. The primary relay units and terminal relay units are, therefore, provided with recorders and transmitters suitable for the particular system of transmission employed.

In the limiting cases an exchange or switching office may consist solely of incoming and outgoing subscribers' lines with no trunk to other offices or an exchange may consist solely of incoming

and outgoing trunks, i. e., it may function as a through trunking office; in either case, appropriate storage units would be provided.

In order to provide for the most efficient use of intermediate relay units which are accessible to a plurality of primary units, the invention provides a novel means for distributing the traffic thereto. This apparatus identified generally as the "primary distributing mechanism" is interposed between the primary relay units and the intermediate relay units. Generally similar apparatus conveniently called "secondary distributing mechanism" is interposed between the intermediate relay units and the terminal relay units.

The primary distributing mechanism includes among other things, a distributing device or "solicitor" PS which, in cooperation with level switching mechanisms incorporated in the several intermediate relay units and a "level switcher" LEV (Figs. 22, 25 and 28) determines the particular order in which the intermediate units are made available for the reception of messages. A separate solicitor and level switcher is provided for each group of intermediate relay units. These are distinguished by the suffixes 1, 2 and 3 applied to the references PS and LEV as shown particularly in Figs. 22, 25 and 28. Preferably, distribution of traffic to the intermediate units is made in accordance with the amount of message matter in storage in the several units so that the units are kept uniformly loaded and excessive accumulation of messages in one or more of the units is effectually avoided.

Associated with each solicitor PS is a control device or time assigner PT which determines the order in which the primary units are connected with the intermediate units for the transfer of messages. The time assigners thus effectually prevent simultaneous seizure of the same intermediate unit by two primary units.

The secondary distributing mechanism includes a solicitor SS for each group of lines or trunks having a common destination. One such group is shown for each of the exchanges, the group for exchange A comprising the trunk lines T_a extending to exchange B and the group for exchange B comprising the trunk lines T_b extending to exchange A. Time assigners ST_1, ST_2 and ST_3 of which there is one for each group of intermediate units, control the order in which the intermediate units of the groups establish transmitting connections to the terminal units TR. In the case of messages directed to the terminal units TR_3 and TR_4, all of the time assigners cooperate with the solicitor SS provided for that trunk group. Moreover, these time assigners are suitably interlocked to govern the order in which the intermediate unit groups are conditioned for transmission of the different classes of messages stored therein.

In order to provide the necessary supervision of traffic going through the system, there is provided at each exchange a "supervisory switchboard" SB interconnected with the various relay units and arranged to indicate any non-standard condition that may arise. For example, when the storage capacity of any relay unit becomes substantially exhausted, this condition is immediately indicated by operation of an appropriate signal. Other signals are operated in the event that transmission of the foremost message in storage at any intermediate unit is unduly delayed.

To prevent stalled messages from excessively delaying succeeding messages stored in the same intermediate unit, means is provided whereby the attendant or supervisor is enabled to transfer the message to an "auxiliary unit" AR of which one is provided for each group of intermediate units. To this end the bus circuits outgoing from the intermediate units and the receiving trunks of the terminal units are extended through normally closed jack switches at the supervisory switchboard. The receiving trunks for the auxiliary units terminate in plug ended cords at the switchboard which may be inserted in the jacks as required to enable the auxiliary units to receive a message from any intermediate unit. This automatically opens the jack switches to disconnect the terminal unit which thus remains unavailable and the message remains for the moment stored in the auxiliary unit. The transmitters of the auxiliary units will transmit stored messages to the desired terminal when the cause of the break has been removed and the plug ended cord of a particular auxiliary unit is removed from its jack.

In addition to the equipment above described, the supervisory switchboard is provided with one or more "emergency relay units" ER, for receiving messages that for any reason cannot be forwarded to their destination in the usual way.

Another relay unit FAR is arranged to receive messages transmitted with faulty address or directing signals or messages which have lost their directing signal or have been mutilated in transmission so that they represent unassigned addresses. These relay units are preferably arranged to retransmit the messages to standard telegraph printers TP which reproduce them in printed form. The attendant or supervisor may either make the necessary corrections to insure proper forwarding or notify the sending subscriber of the non-delivery of the message.

Messages removed from their regular course through an exchange to a printer may be returned to the system for automatic direction and transmission by means of a suitable transmitter ET at the supervisory switchboard operating with a primary unit PR_6 similar to and grouped with the primary units serving the subscribers' lines and incoming trunk lines. This transmitter may be of any suitable and well-known type.

Subscriber's station equipment

While transmitting and receiving apparatus of any suitable and well-known type may be provided at the subscriber's station, it is preferred to employ keyboard operated telegraph typewriters of the start-stop type for the reasons hereinbefore explained. Transmitters T_s and receivers R_s of this character are shown diagrammatically in Figs. 24 and 27. As herein shown, a calling line CL extends from the transmitter to the exchange and a separate receiving line RL extends from the exchange to the receiver. It will be understood, however, that transmission and reception may be carried on over a single line if desired.

Referring to Fig. 24, the transmitter Ts includes a switch 1 which is closed upon the depression of any of the keys of the keyboard. Closure of this switch energizes a cam shaft release magnet 2 provided there is a battery potential on the line CL to which the magnet is connected. Energization of the magnet 2 releases the cam shaft for a single revolution whereby transmitting switches 3, one for each of the five components or intervals of the code signals, are actuated successively. The particular switches closed upon such actua-

tion is determined in well-known manner by the particular key operated. Each group of signal impulses is preceded by a start impulse and followed by a stop interval, the first being a current impulse and the latter a no-current condition.

A signal lamp 4 at the transmitter is lighted to indicate that the line CL is in condition for transmission. Opening of the line as when the associated relay unit is unable to receive message matter extinguishes the lamps to call attention to this condition. Moreover, when the line is open, magnet 2 cannot energize to release the transmitter cam shaft, hence the transmitter remains locked out until the line is closed again. As shown in Figs. 21, 24 and 27 a manually operable switch MS is provided for opening the calling line when temporary interruption of same is necessary for any reason.

Receiver Rs includes the usual line magnet 5 which responds initially to the start impulse to release the receiver cam shaft and then to the signal impulses to set the selector mechanism for selection of a printing bar or a function performing element. Through the medium of a manually operable switch 6_a, the magnet 5 may be disconnected from the line RL, thus marking the line as out of service so that it cannot be seized by the terminal unit at the exchange.

Relay units

In general.—The relay units employed in the system disclosed in the present application are modifications of the basic unit shown in the prior application Serial No. 319,047. As indicated by the legends in Fig. 3, each relay unit includes a signal responsive mechanism or recorder, signal storage mechanism, and a signal transmitter.

The storage mechanism of all the units are substantially identical with that of the prior application, but the recorders and transmitters of certain of the units have been modified to adapt them for the different operating conditions met with in a comprehensive telegraph system. Thus, the recorders of the primary relay units associated with the supervisors' and subscribers' lines CL and the trunk lines connecting exchanges A and B (Figs. 1 and 2) are arranged to receive signals transmitted by the start-stop system. The other relay units of the exemplary system are equipped with recorders for receiving signals transmitted by the simultaneous system as explained in detail in the prior application.

The transmitters of the various units are similarly modified, those for the primary and intermediate units and for the terminal units associated with the trunk lines to exchanges C and D transmitting simultaneous signals. The remaining terminal units including those associated with subscribers' receiving lines RL and with the trunk lines connecting exchanges A and B are equipped with start-stop transmitters.

Relay unit storage mechanism.—As the storage mechanism for all of the relay units is substantially like the mechanism disclosed in the prior application, a brief description will suffice. In general, this mechanism comprises a storage medium, preferably a flexible band 6 (Figs. 3 and 5) consisting of a plurality of individual signal carriers 7 linked together to form an endless chain. Each carrier or link 7 is equipped with a set of individually movable control elements or pins 8' which may be set in different permutational combinations representing character or control signals. In the present instance, there are five pins in each link corresponding to the five components of the permutational signal ordinarily employed in telegraphic transmission.

The recorder and transmitter of the relay unit are associated with the chain at spaced points hereinafter called respectively the recording point and the transmitting control point. That portion of the chain between the recording point and the transmitting control point constitutes a storage section of variable capacity, while the remainder of the chain constitutes a supply section from which blank links may be delivered according to the variable requirements of the recorder.

For the reason set forth in detail in the prior application, the storage chain in passing from the recording point to the transmitting control point, is arranged to form a series of loops 4' which may vary in length as the quantity of message matter in the storage section increases or decreases. A corresponding arrangement of loops 5' is provided in the supply section, these loops varying in length to compensate for the variations in the loops 4', fixed over-all length of the loops in the storage and supply sections being thereby maintained. A blanker 60' acts to set all of the pins in blank or non-pushed position before the chain is fed into the supply section.

To permit movement of the storage chain past the recording and transmitting points at high speeds, relatively short sections of the chain immediately associated with the recorder and transmitter, are arranged for advancing movement independent of the main body of the chain in the storage and supply sections. These sections comprise short loops of low inertia hereinafter called the recorder loop 6' and the transmitter loop 7'. The chain is fed automatically into these loops from the supply and storage sections by drive mechanisms of the type disclosed in said prior application. The mechanism for advancing the chain in the loops 6' and 7' past the recording and transmitting points will be described hereinafter in connection with the various types of recorders and transmitters.

Primary relay unit start-stop recorder

Signal reception.—In the exemplary system (Fig. 1) the primary relay units associated with subscribers' calling lines CL and with start-stop trunk lines T_b are equipped with recorders adapted for the reception of start-stop signals. Due to the character of these signals, operation of the recorder is intermittent, the start impulse of each signal initiating an operating cycle which terminates with the stop interval of the signal. During the cycle the five significant impulses of the signal are recorded on the storage medium or pin chain by appropriate setting of the pins presented at what may be called the recording control point.

In order to properly time the various operations of the recorder with respect to the incoming signal impulses, the various operating elements are actuated or controlled by a cam shaft driven substantially in synchronism with the cam shaft of the transmitter at which the signals originate. The cam shaft also controls the feed of the pin chain through the recorder loop so that at the proper time in each cycle a blank link is presented at the recording position. It will be understood, of course, that the cam shaft and other parts of the recorder are mounted in suitable framework (not shown) which is rigidly secured to the framework of the relay unit.

As explained hereinbefore, the primary units are arranged to retransmit stored messages by the simultaneous method of transmission which is preferred because of its relatively high speed. Start-stop transmission is inherently slower than simultaneous transmission. Hence, in order to properly coordinate the recording and transmitting apparatus of a unit, the recorder is provided with means for initiating retransmission only after a message has been completely received as indicated by an end-of-message signal. Additional means is provided for running out a plurality of blank links following each message so that all of the message links may be presented at the transmitting point without waiting for additional incoming message signals.

Pin setting mechanism.—Referring to Figs. 4 and 5, the pin setting mechanism in its preferred form, comprises a series of pin pushing devices successively conditioned for selective operation under the control of successively received signal units. As shown, said devices comprise five push rods 21 supported and guided on a frame or car 22 for movement toward and from the chain link at the recording point. The rods are spaced apart laterally to aline axially with the pins of the link so that each rod when actuated is effective to push the associated pin into what may be called the "pushed" position.

Actuation of the push rods 21 is effected by power driven means including a selectively operable reciprocatory actuator 23 acting through the medium of push bars 24 articulated to the outer ends of the push rods for limited pivotal movement in a vertical plane. Each push bar is formed with a head 25 adapted to be conditioned for selective operation by movement into the path of the actuator when the bar is elevated by a cam 26 fast on a cam shaft 27. One such cam is provided for each push bar, the cams being arranged in staggered relation so that the bars are elevated in a definite sequence corresponding to the five impulses of the incoming signal. Coiled springs 28 (Fig. 5) connected between the frame and upstanding lugs 29 on the push bars tend to hold the bars as well as the push rods 21 in a withdrawn position.

The actuator 23, as herein shown, is in the form of a flat bar having at one end a generally T-shaped head presented for engagement with the heads of the five push bars 24. The other end of the actuator is pivoted as at 32 to one arm of a floating lever 33 whose other arm is adapted to be blocked selectively in accordance with the character of the incoming signal impulses as will be explained hereinafter. The floating lever 33 is rockably mounted on a stud 34 carried on a crank arm 35 fast on an oscillatory shaft 36 journaled in the frame of the recorder. When the shaft is oscillated, the pivotal point of the floating lever 33 is first shifted toward the push bars and then retracted. If the free end of the floating lever is not blocked in the active stroke of the lever, it turns on a fulcrum at the point of connection with the actuator 23 due to the resistance of the spring 28 of the raised push bar which the actuator engages. The push bar thus remains in its retracted position under these conditions and the corresponding pin of the chain is not pushed. If the free end of the floating lever is blocked against movement on the active stroke, the lever becomes fulcrumed at the free end and the opposite end with attached actuator is advanced to actuate the elevated push bar 24 and its associated push rod 21 and thereby push the aligned pin of the pin chain into its "pushed" position.

Oscillation of the shaft 36 must be accurately timed with respect to the elevation of the push bars and both must be synchronized with the incoming signal impulses. This timing is accordingly controlled by a cam shaft 41 hereinafter called the main recorder cam shaft.

The main recorder cam shaft.—The main recorder cam shaft 41 is adapted to be driven cyclically at a speed accurately timed with respect to the speed of the transmitter from which the recorder receives its signals. As herein shown the cam shaft is adapted to be driven cyclically by a suitable friction clutch indicated generally at 42 which is engaged automatically in response to the start impulse of the signal and which is disengaged coincident with the reception of the stop interval of the signal. The clutch 42 which may be of any suitable and well-known type comprises driving elements 43 and 43^a constantly driven from a gear 44 on the main drive shaft of the relay unit and driven elements 45 and 45^a, element 45 being loosely screwed on the threaded cam shaft.

Engagement ad disengagement of the clutch elements is effected through the medium of a clutch finger 46 integral with the driven element 45. When the finger is blocked, rotation of the cam shaft is interrupted and, when the finger is released, a spring 47 tends to rotate the element 45 which, by reason of its threaded connection with the shaft 41 is thereby moved into driving relation to the driving element of the clutch. The cam shaft is then rotated until the finger is again blocked at the end of the cycle. A spring pressed detent 45^c engaging in a notch in the driven element 45^a acts to position the cam shaft when the clutch is disengaged.

In the particular embodiment illustrated the cam shaft 41 is arranged to make one complete revolution for each of the first six signal intervals. The shaft thus executes six revolutions for each signal cycle. A double cam device 48 on the shaft 41 acting on a cam follower 48_a oscillates the shaft 36 and swings the floating lever 33 in timed relation to the incoming impulses.

The main recorder cam shaft also serves to drive the cam shaft 27 in timed relation to the signal impulses. In the present instance the drive is effected through speed reducing gearing including a worm 49 fast on the shaft 41 meshing with a worm gear 49_a on a cross shaft 50. The shaft 50, in turn, has a spiral pinion 51 meshing with a spiral gear 52 fast on the shaft 27. The gear ratios are such that the shaft 27 executes one complete revolution in each signal cycle while the main cam shaft executes six revolutions. Thus as each push bar is elevated, the floating lever 33 and associated actuator 23 execute an active stroke whereby to operate the pin pushers 21. The pushers are actuated, however, only when the free arm of the floating lever is blocked and this is controlled in accordance with the signal impulses by a line relay LR connected to the incoming line and adapted to respond to the current and no current intervals of the signal. The relay serves the additional function of initiating the operating cycle of the main recorder shaft by engaging the clutch 42.

Signal reception.—In the exemplary telegraph system the primary relay units are associated individually with subscribers' calling lines and with incoming trunk lines. Under these condi-

tions the line relay LR is connected directly to the line. The relay may be of any suitable and well-known type having a light, quick acting armature 55 adapted to respond to the current and no current intervals of the signals. A coiled spring 56 acts to hold the armature away from the core of the relay, the armature being drawn to the core when the relay is energized.

As herein shown, the armature 55 is formed with an extension 57 adapted to act alternatively as a latch for the floating lever 33 and the clutch finger 46. To this end the latch and clutch finger are arranged in side-by-side relation at one side of the relay as shown in Fig. 6, and the armature is supported for lateral movement whereby the latch may be positioned for cooperation with either of these elements. As herein shown, the armature 55 is pivoted on a horizontal axis between spaced lugs 58 depending from one edge of an elongated bar 59 slidably supported for endwise movement in the framework of the recorder. A coiled spring 60 normally acts to hold the bar retracted with the latch 57 occupying the dotted line position of Fig. 6 in which it is interposed in the path of the clutch finger 46. Accordingly, when the line relay responds to the start impulse of a signal, the latch is withdrawn by the rocking of the armature about its pivot, thereby releasing the clutch finger and engaging the driving and driven elements of the main recorder cam shaft clutch 42.

In order to enable the latch 57 to cooperate with the floating lever 33 in controlling the actuation of the pin pushers and to prevent disengagement of the clutch 42 as the relay responds to the succeeding impulse of the signal, means is provided for shifting the armature support to its advanced position (shown in full lines in Fig. 6) immediately after the release of the cam shaft. This means, as herein shown, comprises a cam 61 fast on the cross shaft 50 which, as above explained, is driven from the main cam shaft. The cam 61 acts on a follower roller 62 carried on a pivoted bracket 63 which has an integrally formed, upwardly projecting finger 64 engaging the end of the armature supporting slide. The timing of the cam 61 is such that the armature is shifted to the right and the latch 57 is positioned for cooperation with the floating lever 33 throughout the five intervals of the signal following the start interval. Thereafter the supporting slide and armature are returned to retracted position to render the latch effective to block the clutch finger 46 upon receipt of the stop interval of the signal.

Chain advance.—During the reception of signals at the recorder, the recorder loop of the storage chain is advanced intermittently to present a blank link at the recording position in each signal cycle. At the end of the message, the chain is advanced continuously to introduce a supply of blank links sufficient to allow the last link of the message to be presented at the transmitting point before the next message is received. Separate power driven means herein shown as positively acting clutches 71 and 72 (Fig. 4) are provided for imparting the intermittent and continuous movements to the chain through the medium of a common drive mechanism comprising a spur gear differential 73 of well-known construction having the usual terminal gears 74 and 75 and an intermediate gear 76.

Referring to Figs. 4 and 5, the recorder loop 6' of the pin chain is carried over a pair of feed sprockets 53' fast on a shaft 175' suitably journaled in the framework of the recorder. A pinion 77 fast on this shaft meshes with the intermediate of the differential 73. One terminal gear of the differential, in this instance the terminal gear 74, is adapted to be driven by a pinion 78 fast on a start-stop shaft 79 arranged to be driven intermittently by the clutch 71. The ratio of the gearing is such that the feed sprockets are effective to advance the chain three links for each revolution of the start-stop shaft.

While the clutches 71 and 72 may be of any suitable character, they are herein shown as bar type clutches similar to the clutch disclosed in the Colman Patent No. 2,013,649 of September 10, 1935. As shown in Figs. 4 and 5, the clutch 71 includes a driving member 80 concentric with the shaft 79 and a driven member 81 in the form of an arm fast on said shaft and projecting radially therefrom adjacent one end of the driving member. The member 80 is constantly rotated from the main drive shaft 67' (Fig. 5), of the relay unit through the medium of a gear 82 integral with the member and arranged to mesh with a pinion 84' on the drive shaft.

Formed on the end of the driving member 80 adjacent the arm 81 is a disk 83 having a plurality of peripheral teeth 84 presenting abrupt radially disposed shoulders facing in the direction of rotation of the disk. Three such teeth are provided in the present instance and the shaft 79 may be started and stopped to advance the pin chain one link per cycle. Cooperating with the teeth to connect and disconnect the driving and driven members is an L-shaped bolt 85 slidably supported and guided by the arm 81 and having its end portion overlying the periphery of the disk 83. The shank of the bolt extends substantially radially of the disk as shown in Fig. 5 and is pivoted eccentrically to a lever 86 mounted on the start-stop shaft 79 for limited angular movement relative thereto. A torsion spring 86_a urges the lever in a clockwise direction as viewed in Fig. 5, thus tending to enter the bolt in the notches of the driving disk.

The bolt 85 of the clutch 71 is adapted to be shifted to a disengaged position and held there by a detent 87 movable into or out of the path of any one of a plurality of radially projecting clutch fingers 88 formed integrally with the lever 86. There are three of these clutch fingers, one for each notch in the driving disk 83. When a finger is blocked by the detent, continued rotation of the start-stop shaft through a small angle lifts the bolt out of the notch in the driving disk and thereby interrupts the driving connection for the shaft and brings the shaft to rest. When the detent is withdrawn from the path of the clutch finger, the torsion spring acts to swing the lever relative to the shaft and thus reenter the bolt in a notch in the disk.

The withdrawal of the detent 87 to engage the clutch is effected under control of the signal receiving mechanism in response to each incoming signal. As the signals are received at random with respect to the cyclic operation of the relay unit, means is provided for synchronizing the withdrawing movement of the detent with the rotation of the driving member of the clutch. For this purpose the free end of the detent is arranged for interlocking engagement in a notch 89 in the tip of each clutch finger. This interlocking engagement is interrupted to relieve the detent periodically by cam surfaces 90 on the periphery of the disk which engage the overlying

portion of the bolt 85 at predetermined points in the cycle and thus rock the lever 86 to lift the clutch finger out of engagement with the detent.

As herein shown (Fig. 4) the detent 87 is formed with a hub portion 91 loosely mounted on a detent actuating rock shaft 92 extending generally parallel to the start-stop shaft. A torsion spring 93 connected at one end to the detent 87 and at the other end to a collar 94 pinned to the shaft 92 provides a yieldable connection whereby movements of the shaft may be imparted to the detent. As herein shown, the collar 94 is formed with a generally L-shaped arm 95 which serves as a back stop for the detent. A magnetic set device 96, of well-known construction, is arranged to hold the detent in either its entered or withdrawn position.

The shaft 92 is rocked to detent withdrawing position at the end of each signal cycle through the medium of a cam 97 fast on the cam shaft 27 coacting with a follower roller 98 carried on a crank arm 99 fast on the rock shaft. A spring 100 acting on the arm 99 tends to return the shaft to detent entering position. The cam 97 has a single lobe positioned to momentarily engage the follower roller 98 as the shaft 27 completes its cycle and thus rocks the shaft 92 to the position shown in Fig. 4. As the timing of the cam is at random with respect to the timing of the clutch 71, means is provided for holding the shaft 92 in operated position independently of the cam until the clutch bolt is entered. As herein shown, this is accomplished by a pivoted latch 101 urged by a spring 102 into engagement with a latch member or finger 103 fast on the shaft 92.

The rocking of the shaft 92 tensions the spring 93 sufficiently to overcome the pull of the magnetic set device 96 when the clutch finger is lifted by the cam 90 out of engagement with the detent 87. The detent is then quickly rocked to its withdrawn position and the bolt 85 is permitted to drop into a notch in the disk 83 as soon as the notch is presented thereto. Upon the entry of the bolt the detent should return to normal rest position in time to effect withdrawal of the clutch bolt at the end of the cycle. To this end, the latch 101 is withdrawn through the action of a three lobed cam 104 on the start-stop shaft 79. The cam is timed so that the detent shaft is fully restored before the clutch driving element completes a third of a revolution and the detent 87 is thus positioned to block the next clutch finger and disengages the clutch at the end of the cycle. In this way, the chain is advanced link by link through the recording position.

In order to insure the full advance of the pin chain in the recorder loop during each signal cycle, the start-stop shaft 79 is driven in synchronism with the other mechanism of the relay unit to advance the chain at a rate of 3,600 cycles per minute. Thus, regardless of the timing of the engagement of the clutch 71, with respect to the start of the signal cycle, the chain advance is always completed as the cam shaft 27 completes its revolution. The cam shaft, as before explained, executes a single revolution for each incoming signal which, in start-stop transmission, are timed at approximately 350 code combinations per minute.

Because of the above difference in timing, means is provided for maintaining the pin pushers 21 in alignment with the chain link at the recording position throughout the major portion of the signal cycle. To this end the push rod supporting car 22 is mounted in vertical ways (not shown) for movement through a step substantially equal to the width of a chain link. Journaled on the car is a shaft 106 having a pair of sprocket wheels 107 meshing with the chain. Through this engagement, the car is carried along with the chain in its upward movement by the drive sprockets 53'. At the same time the shaft 106 is being driven at a speed such as to return the push rod car to its lower waiting position at the end of the signal cycle. To this end it is operatively connected through a one-way drive mechanism 108 (the purpose of which will appear presently) with a shaft 109. The spring on the pawl of this drive mechanism is adjusted to secure this result. The shaft 109 is driven from the cross shaft 50 of the signal receiving mechanism through the medium of a worm 110 and worm wheel 111, the worm 110 being fast on an extension 112 connected to the shaft 50 through the medium of universal joints 113 and 114 and an intermediate shaft 115. The universal joints permit the driving shaft to follow the movements of the car without interfering with the proper operation of the apparatus.

End-of-message operations.—At the end of each message the transmitter of the relay unit is conditioned for starting and a plurality of blank links are run through the recording position at high speed so that the last link of the message can be presented to the transmitting point. The means for advancing the chain under these conditions includes the clutch 72 arranged to drive a shaft 116 which has a pinion 117 meshing with the terminal gear 75 of the chain advance differential 73. The clutch 72 is similar in all respects to the clutch 71 including a driving member 80_a rotated continuously through the medium of a gear 82_a meshing with the pinion 84' of the main drive shaft 67' of the relay unit. The clutch 72 is engaged and disengaged by a detent 118 cooperating with clutch fingers 88_a similar to the clutch fingers 88 of the clutch 71 except that the fingers 88_a are not notched to interlock with their associated detent. As shown in Fig. 4, the detent 118 is carried on a rock shaft 120 journaled on the frame of the machine and a spring 121 acting on an arm 122 fast on the shaft normally urges the detent into blocking relation to one of the clutch fingers.

The end of a message is marked by an end-of-message signal consisting in this instance of three blank links. For detecting this signal there is provided an end-of-message feeler CF1 comprising a bar 216' extending transversely of the pin chain and having a series of elongated shoes 215' (Fig. 5) adapted for cooperating with the pins of not more than three successive links of the chain. There is one shoe for each of the five rows of pins on the chain, only one shoe being shown in Fig. 4. A spring 123 urges the shoes into engagement with the pins and as long as one or more pushed pins are encountered in any of the three links spanned by the shoes, movement of the feeler is blocked. When, however, the three or more blank links appear, the feeler is permitted to move to the right (as viewed in Fig. 4) against a fixed stop 124.

Movement of the feeler CF1 serves to trip the detent 118 and thus engage the clutch 72. For this purpose the feeler bar 216' is linked to a crank arm 125 (shown in broken lines in Fig. 4) fast on a vertical shaft 126 having a radially projecting arm 127 to which a push rod 128 is connected by a ball and socket joint 129. The push rod is normally held against a stop 130

by a spring 131 and in this position its tip engages a lug 132 projecting laterally from one side of the detent 118. Upon movement of the feeler incident to the detection of the end-of-message signal, the shaft 126 is rocked and the push rod swings the detent 118 out of the path of the clutch finger 88a, thus engaging the clutch. The shaft 116 is thereupon driven at a speed sufficient to advance the chain through the recorder loop at a rate of 3,600 links per minute. In this operation, the shaft 109 remains stationary due to the one-way connection provided by the drive mechanism 108. As stated above, the motion of the car is limited to about one chain link distance at which point it engages a fixed stop (not shown) and the pawl of mechanism 108 slides over the teeth of the ratchet as the ratchet is driven by the chain.

The advance of the chain continues until a plurality of links, in this instance 150 links, have been inserted after the end-of-message signal. As the 150th link passes the recording point, the detent 118 is returned to entered position to disengage the clutch and interrupt the chain advance. This is accomplished by raising the tip of the push rod 128 out of the path of the lug 132 so that the spring 121 may rock the detent to its entered position.

The means for lifting the push rod 128 includes a cam 133 fast on a shaft 134 which is driven at relatively low speed from the shaft 116 through a vertical shaft 135 coupled with the other shafts by spiral gears 136 and 137. The cam 133 is formed with a lobe 138 occupying less than one 150th of the circumference of the cam. The ratios of the driving gears are such that the cam makes one complete revolution as 150 links of chain pass the recording point. The lobe 138 is so placed that as the 150th link passes the recording point a bar 139 is shifted to raise the free end of the push rod 128 out of the path of the lug 132. The detent 118 is thereupon returned to entered position by the spring 121. The push rod 128 now rides over the top of the lug 132 until another link having one or more pushed pins is moved past the feeler CF1 to shift the same to actuated position and withdraw the push rod 128 to the right. Thus the chain advancing mechanism is conditioned for the next operating cycle.

Mounted on the shaft 134 is a second cam 141 adapted to open the calling line and thus lock out the subscriber's transmitter during the interval that the blank links are running through the recording loop, and also to initiate the operation of a message counting mechanism which in turn controls the operation of the transmitter. For this purpose the cam 141 is formed with a lobe 142 which, when the cam is in its normal rest position, engages one arm of a pivoted lever 143 to close a switch 145 connected in series in the calling line. When the lobe 142 is moved out of the path of the lever as the cam starts its rotation, a spring 147 rocks the lever in a clockwise direction and opens the switch. This opening of the line prevents energization of the cam shaft starting relay 2 (Fig. 24) of the transmitter, thereby locking the transmitter inoperative until the recorder is again in condition to receive signals. Due to the high speed with which the chain is advanced, the lock-out period does not exceed two and one-half seconds. Upon further rotation of the cam 141 the lobe 142 engages a laterally projecting pin 151 on a crank arm 152 carried by a rock shaft 153 to initiate the operation of the message counter. For this purpose, the rock shaft is provided with a clutch controlling detent 154.

Message counter.—The message counter as incorporated in the primary relay units, serves the same general purpose as the storage indicator of the basic relay unit shown in the prior application. Its use is desirable because of the different rates at which messages are received and transmitted by the units. The function of the counting mechanism is to count the completed messages entering and leaving the storage section of the signal storing mechanism and to condition the chain advance mechanism of the transmitter to advance the chain to the transmitting point whenever one or more messages are available for transmission.

To accomplish the foregoing result, the counter includes a part arranged to move a predetermined distance in one direction following the recording of each message, thereby counting the number of messages passing into the storage section, the part moving a corresponding distance in the opposite direction following the transmission of each message whereby to count and subtract the messages passing out of the storage section. Such movements are controlled jointly from the recorder and the transmitter, the part being differentially driven from separate power driven means initiated in operation automatically as the end-of-message signals pass the recording point and the transmitting point respectively.

Referring now to Fig. 7, the movable part of the message counter, as herein shown, comprises a shaft 161 journaled on the framework of the relay unit for rotation in one direction by a connection with the recorder and for rotation in the opposite direction by connection with the transmitter. On the shaft is mounted a cam 162 adapted to coact with a follower roller 163 carried on a pivoted lever 164. The lever is connected by a link 165 with a crank arm 166 fast on the rock shaft 301' which carries the finger 300' for entering and withdrawing the latch L9 of the floating lever FL9. When no messages are present in the storage section, the cam lobe acts to hold the lever 164 in the position shown in the drawing whereby the latch is withdrawn from the path of the floating lever. When the shaft 161 is rotated away from the zero position upon the transfer of a message to the storage section, the lobe of the cam is moved away from the cam follower and the lever 164 is rocked to its active position by a spring 167 thus withdrawing the finger 300' and entering the latch L9 provided such entry is not prevented by other control means. The other control means referred to is the governor controlled mechanism described in the prior application for holding the latch L9 withdrawn until the transmitter is in condition for operation as indicated by the position of the governor or J-cam shaft of the transmitter.

The means for driving the message counter shaft 161 differentially from the recorder and the transmitter, comprises a spur gear differential 168, the two terminal gears 169 and 170 of which are rigid with intermittently operable shafts driven respectively by the clutches 171 and 172. The intermediate member of the differential is in the form of a gear 173 meshing with a gear 174 fast on the message counter shaft 161. The gear 173 carries a pair of intermeshing pinions 175 meshing respectively with the terminal gears 169 and 170 of the differential.

As herein shown, the gear 174 on the message counter shaft is provided with a scale graduated for cooperation with a pointer 176 to indicate the number of messages in storage. In the particular embodiment illustrated, the mechanism is arranged to count eleven messages, the shaft 161 being rotated in a counter-clockwise direction through one-twelfth of a revolution for each message recorded.

The power driven means for driving the counter to register incoming messages, that is, the clutch 171, is a positively acting bar type clutch similar to the clutch 71 hereinbefore described. Briefly, it includes a driving member having an integrally formed gear 177 meshing with an intermediate gear 178 driven by a pinion 179 on the constantly rotating drive shaft 67' of the relay unit. The driving member is engaged with a driven member fast on the intermittently driven shaft carrying the terminal gear 169 of the differential by withdrawal of the detent 154 from the path of a clutch finger 180.

As above explained, withdrawal of the detent 154 is effected by the cam 141 which is started in rotation in response to the end-of-message signal. The cam is shaped to permit detent 154 to return to blocking relation with respect to the clutch finger 180 upon movement of the cam through a single step corresponding to the passage of one chain link through the recording position. The clutch is, therefore, disengaged and the rotation of the shaft 161 interrupted after movement through a step sufficient to register one message on the counter. The drive in this instance is such as to turn the shaft 161 and gear 174 in a counter-clockwise direction (as viewed in Fig. 7) thus locating the numeral 1 immediately below the pointer 176. As additional messages are recorded, the shaft 161 is stepped around to add up the messages passing into storage.

The clutch 172 which drives the message counter in response to the transmission of each message is a positively acting bar clutch similar to the clutch 171. It includes a driving member 181 having an integrally formed gear 182 meshing with a pinion 183 on the main drive shaft 67'. Thus the driving member of the clutch 172 is rotated reversely with respect to the driving member of the clutch 171 so that the clutch 172 is effective to drive the counter shaft 161 in a clockwise direction to subtract from the messages recorded thereon. The driving member of the clutch 172 is engaged with the driven member by withdrawal of a detent 184 from the path of a clutch finger 185, the driven member being fast on the shaft which carries the terminal gear 170 of the differential.

Withdrawal of the detent 184 is effected by the main controller or cam shaft 232' of the transmitter which, as explained in the prior application, executes a single revolution in a plurality of steps in the transmission of each message. This shaft is provided with a plurality of cams including a cam 186 (Fig. 7) arranged to withdraw the detent 184 as the J-cam shaft returns to its normal rest position following the transmission of a complete message. Such withdrawal is effected by the cam acting on a follower roller 187 on one arm of a pivoted bell crank 188 whose other arm is connected by a link 189 with a crank arm 190 fast on a rock shaft 191 on which the detent 184 is mounted. Thus, as each message is withdrawn from storage and relayed toward its destination by the transmitter, the message counter is operated to register this condition by subtracting from the messages previously registered. When all of the messages in storage have been transmitted, the message counter shaft 161 is returned to its zero position whereupon the cam 162 acts to withdraw the latch L9 from the path of the floating lever FL9 and thus interrupt the chain advance at the transmitting point.

Primary relay unit simultaneous recorder

Before proceeding to the description of the primary relay unit transmitters, all of which are alike regardless of the type of recorder employed, the recorders for the primary units associated with interoffice trunk lines arranged for simultaneous transmission will be discussed briefly. No detailed description is believed to be necessary as these recorders are identical with the recorder shown and described in the prior application, Serial No. 319,047.

Referring to Fig. 10, the simultaneous recorder comprises generally a series of five pin pushers 154' slidable in stationary guides 155' in a direction axially of the pins in the chain link at the recording point. The push rods are arranged for actuation by a series of floating levers FL1 to FL5 (only one being shown) actuated selectively under control of latches L1 to L5 controlled by signal responsive electromagnets 156' (Fig. 21). These magnets are connected to the respective signal conductors of the incoming trunk line Tc and respond to the signal impulses transmitted thereover by the transmitter at the distant exchange.

The floating levers FL1 to FL5 are pivotally mounted intermediate their ends on a rod 157' suspended between arms 158' from a shaft 159' which is continuously oscillated by a cam 160' on a driven shaft 161' and which coacts with a double follower 163' on the shaft 159'. One end of each floating lever is pivotally connected to one of the push rods and the other end of each lever is adapted to engage its corresponding latch when the latter is actuated by energization of its magnet 156'. Thus the floating levers corresponding to energized magnets are effective in their active stroke to shift the associated push rods and thereby push corresponding pins of the chain.

The chain is fed through the recorder loop to present blank links to the pin pushers by a pair of sprocket wheels 53' driven by a clutch as described in the prior application. At each link passes into the storage section of the relay unit, storage indicator mechanism like that disclosed in the prior application is actuated in the usual way and through appropriate mechanism causes the chain to be fed to the transmitter loop, the chain in turn acting to start the transmitter in operation. Should the supply of blank links become exhausted, that is, when the full storage capacity of the unit is reached, the loop indicator acts to close a full storage stop switch 540'.

Primary relay unit transmitter

In general.—The transmitters provided in the primary relay units are all alike and are substantially similar to the transmitter of the basic relay unit shown in the prior application, except for the modifications noted hereinafter. Briefly, the function of the transmitter is to relay or retransmit messages from the primary unit to an intermediate relay unit in a selected one of the three groups assigned for messages of different classes. In effecting this retransmission, the transmitter operates through a four-part message cycle in-

stead of a three-part cycle as in the prior application, first to selectively initiate the operation of the primary distributing mechanism associated with the proper group of intermediate units, second to automatically test the trunk line assigned by the distributing mechanism, third to automatically initiate the transmission of the message over the assigned path, and fourth to free the path and condition the apparatus for the succeeding message.

The first part of each message cycle involves the presentation of the class-of-message signal at an auxiliary control point adjacent the transmitting control point of the transmitter loop whereupon a simple selector mechanism including a separate set of feelers CMF (Figs. 10 and 11), hereinafter called the class-of-message feeler, operates under control of this signal to mark the transmitter as having a call awaiting transfer to the group of intermediate units designated by the signal. The solicitor of the designated group assigns a particular intermediate relay unit to receive the message. Upon such assignment, the time assigner initiates the next step of the message cycle.

In the second part of the message cycle test signals, in this instance a space signal followed by a blank signal, are transmitted over the assigned path to the intermediate unit to determine the operability of the apparatus involved in the connection. If the signals are incorrectly received at the intermediate unit, the transmitter is stopped in a trouble position and the attendant or supervisor is advised of this condition by operation of an appropriate signal. If, however, the signals are transmitted and received correctly, the next step of the message cycle is initiated.

The third step of the message cycle involves the transmission of the message and is effected by continuing the advance of the pin chain to move successive signal combinations past the control point at which the usual set of signal transmitting feelers STF is located. In such movement the signal combinations stored in codal form on the chain actuate the feelers to effect electrical transfer of the message over the assigned path to the receiver of the selected intermediate unit.

The fourth part of the message cycle is initiated by the presentation of the end-of-message signal to a feeler responsive thereto and operable to interrupt the advance of the chain and to free the transmission path.

Message cycling mechanism.—The four-part message cycle is controlled by a cycling mechanism comprising a governor arranged to be driven at a predetermined speed through four successive steps corresponding to the four parts of the cycle. As herein shown, the governor is of the rotary type and is adapted to travel through a complete revolution in each message cycle. As in the basic relay unit, it comprises the cam shaft 232′ (Fig. 8) hereinafter called the J-cam shaft adapted to be driven by a positively acting jaw clutch 234′ having a dog 242′ for effecting engagement and disengagement of the driving and driven members.

The control of the clutch to effect the several stepping movements of the shaft in the message cycle is accomplished by means of four detents 249′, 249′, 201 and 259′ spaced about the path of movement of the clutch dog. Detents 249′, 249′ and 250′ are identical in construction and mode of operation with the correspondingly numbered detents shown and described in the prior application. The detent 201 is located between the detents 249′ and 250′ thus locating the trouble position between what may be conveniently termed the test position and transmitting position of the cam shaft. For convenience of identification, the various positions of the cam shaft will be referred to hereinafter as the No. 1, No. 2, No. 3 and No. 4 rest positions, it being understood that positions No. 1 and No. 2 correspond to similarly numbered positions of the prior application while the No. 4 position corresponds with the No. 3 position of the prior application.

Detent 249′ is withdrawn to start the message cycle by the approach of the message to the transmitting control point. For this purpose, a feeler CF2 is located within the transmitter loop in advance of the transmitting control point for association with the chain pins on the inner side of the loop as shown in Figs. 10 and 10a. The feeler CF2 has a series of five shoes each consisting of an elongated lower section 192 adapted for cooperation with the pushed pins of two successive links of the chain and a shorter upper section 193 positioned for cooperation with a pushed pin in the next adjacent link. The sections are mounted respectively on parallel sliding bars 194 and 195. The latter bar is formed with a projecting lug 196 engageable with an upstanding finger 197 on the bar 194 so that the bar 195 may move independently in one direction (to the right as viewed in Fig. 10a) but carries the other bar along when moved in the opposite direction for purposes to be explained presently.

The feeler bars 194 and 195 are yieldably urged to position the shoes into the path of movement of the chain pins and as the first link with one or more pushed pins approaches the shoe sections 193, the feeler bars are both shifted into their outward positions. In this movement, the bar 194 acts through a suitable linkage, such as that disclosed in the prior application, to condition power actuated means for withdrawing the detent 249′ (Fig. 8). This releases the J-cam shaft for its first step, all as explained in detail in the prior application.

In its movement from the No. 1 rest position to the No. 2 rest position, the J-cam shaft interrupts the advance of the pin chain with the first message link, that is, the link containing the class-of-message signal, positioned in engagement with the class-of-message feeler CMF and the second message link positioned at the transmitting control point in engagement with the signal transmitting feeler STF. This is accomplished by means of a cam 302′ (Fig. 7) acting through a pivoted follower 303′ and link 305′ to withdraw the latch L9 from the path of the floating lever FL9.

Chain feelers.—The signal transmitting feeler STF and the class-of-message feeler CMF are located externally of the transmitter loop 7′ with the first-mentioned feeler positioned for engagement by the chain pins at the transmitting control point while the latter feeler is positioned for engagement by the chain pins one link below the control point as shown in Fig. 10. The feeler STF as shown in Fig. 11a comprises five individually movable elements or transfingers 205, there being one for each row of pins on the chain. Each transfinger comprises an upright body portion at the lower end of which is formed a forwardly offset L-shaped depending portion 206 carrying on its tip a shoe 207. Oppositely inclined leading and trailing cam surfaces formed on the shoe intersect at the transmitting control point and are thus positioned for engagement by non-pushed pins passing such point. The trans-

fingers are arranged in side-by-side relation and pivotally mounted between spaced plates 208 and 209 (Fig. 10) to swing about vertical axes. A spring 210 normally urges each transfinger in a direction to position its shoe 207 in the path of movement of a corresponding row of chain pins.

The transfingers STF are utilized in this instance to control transmitting switches TS (Figs. 11a, 21, 24 and 27) for transmitting signal impulses over the selected transmission path to the intermediate relay unit assigned to receive the message. For this purpose each finger is formed with a tailpiece 211 carrying the movable contact of one of the switches TS. The stationary contact of each switch is carried on an individual bracket arm 212 mounted in an insulating block 213 rigidly supported on the framework of the unit at the rear of the transfingers. The brackets 212 provide terminals which are connected to the trunk line conductors as will be described hereinafter.

The switches TS are normally closed by the action of the springs 210 on the transfingers. When a non-pushed pin approaches the control point it engages the leading surface of the corresponding shoe 207 thereby camming the shoe to the left (as viewed in Fig. 11a) and opening the associated switch TS. Conversely, when a pushed pin passes the control point, the shoe is not moved and the switch controlled by the corresponding transfinger remains closed. By this arrangement current impulses are sent over the transmission path under control of the chain on which the signals are recorded.

The class-of-message feeler CMF is generally similar to the feeler STF above described and, as shown in Figs. 10 and 11, comprises a series of five individually movable elements or transfingers 216 or one for each row of pins in the chain. The fingers 216 are of generally L-shaped form and are pivotally mounted between the plate 209 and a lower plate 217 so as to swing on vertical axes. Each finger is equipped with a shoe 218 similar to the shoes 207 and positioned one link below the latter shoe.

The feeler CMF is utilized in this instance to control energization of one of a plurality of selector relays R1, R2 and R3 (Figs. 21, 24 and 27) which constitute a part of the selecting mechanism and which act selectively to start the time assigner of the intermediate relay group to which the message is to be transferred. For controlling these relays, each of the fingers is formed with a tail-piece 219 carrying the movable contact of a switch, the stationary contact of which is carried on a bracket arm 220 mounted in the insulating block 213. As shown in Fig. 11, the tailpieces of alternate transfingers are staggered to permit a more compact assembly of the parts. In the present embodiment the several fingers are operated against the action of their individual springs 220a only by such of the chain pins as occupy non-pushed positions.

Selecting mechanism.—The transfingers 216 are arranged to actuate switches as determined by the class-of-message signals to control the relays R1, R2 and R3 indicated in the portion of the wiring diagram shown in Figs. 21, 24 and 27. Herein, the feelers associated with the first three vertical rows of chain pins (counting from the right in Fig. 11) are equipped with switches 221 all adapted when in normal or closed condition to partially prepare an energizing circuit by way of a conductor 222 for selector relay R1. The energizing circuit for this relay is completed by a switch 223 closed by a cam 224 (Fig. 9) on the J-cam shaft as the shaft approaches the No. 2 rest position and while it remains at that position.

The energizing circuit for the relay R3 is closed jointly by the cam operated switch 223 and a switch 225 controlled by the fifth transfinger of the feeler and remaining in its normal or closed condition unless its shoe is engaged by a non-pushed pin. The latter transfinger also cooperates with the fourth transfinger to control the selection of relay R2. Thus the fifth finger is operated by the engagement of a non-pushed pin on the chain to actuate a switch 226, the arrangement being such that the switch is closed when a non-pushed pin engages the shoe. Closure of this switch together with the closure of the switch for the fourth transfinger completes an energizing circuit for relay R2.

Thus, the relays may be energized selectively under control of class-of-message signals each represented by a single pushed pin in a link. The circuit arrangement illustrated contemplates the use of signals comprising a single positive impulse in the third impulse interval as the first class message signal, a positive impulse in the fourth impulse interval as the second class message signal, and a positive impulse in the fifth impulse interval as the third class message signal. These signals are represented respectively by pushed pins in the third, fourth and fifth rows of the link on which they are recorded.

In order to prevent simultaneous operation of two or more relays in the event that a false class-of-message signal is accidentally incorporated in the message, means is provided for opening the circuits of the relays R2 and R3 in the event that a pin in any one of the first three rows of the class-of-message link is pushed. This means, as herein shown, comprises a relay R4 having a normally closed switch R41 connected in series with the switch 223 and the fifth transfinger which carries the movable contacts of the switches 225 and 226. Relay R4 is connected to conductor 222 in parallel with the relay R1. Thus, if any one or more of the switches 221 for the first three transfingers is closed, the relay is energized and opens its switch to interrupt the current supply to the switches 225 and 226. Accordingly, when a false class-of-message signal is presented to the feeler 216, relay R1 is energized to route the message to the particular group of intermediate units with which this relay is associated, in this case the group assigned to handle first class messages.

Relay R1 on energizing closes its switches R11 and R12, the first-mentioned switch completing a starting circuit for the time assigner PT_1 of the first group of intermediate units to be described hereinafter. The switch R12 prepares a current supply circuit for a group of selector magnets one of which is provided for each trunk line extending to an intermediate relay unit of the first group. Three such trunk lines LT1, LT2 and LT3 with associated selector magnets SM1, SM2 and SM3 are shown by way of illustration in Fig. 21.

Relay R2 when energized closes switch R21 to start the time assigner of the second group of intermediate units. It also closes switch R22 to prepare the current supply circuit for selector magnets SM4, SM5 and SM6 associated with the local trunk lines LT4, LT5 and LT6 (Fig. 24) extending to the intermediate relay units of group 2. Relay R3 through switch R31 starts the time

assigner of the third group of intermediate relay units and through switch R32 prepares a current supply circuit for selector magnets SM7, SM8 and SM9 associated with local trunk lines LT7, LT8 and LT9 (Fig. 27) extending to such units.

It will be understood that the size of the intermediate relay unit groups is not limited to three units nor are the groups necessarily composed of the same number of units. In practice each group will be provided with sufficient relay units to handle the message traffic of the particular class to which that group is assigned. As will be seen by reference to Figs. 21, 24 and 27, the local trunk lines LT1 to LT9 inclusive, are multipled through all of the primary relay units by means of bus circuits B1 to B9, respectively. The bus circuits have been shown extending beyond the primary relay units PR_1 and PR_6 to indicate their connection to other primary relay units of the exchange.

The current supply circuits for the selector magnets are extended to negative battery (indicated throughout the circuit diagrams by an arrow-head) as the J-cam shaft moves out of its No. 2 rest position through closure of a switch 227 (Figs. 9 and 21) by a cam 228 on the cam shaft. When the solicitor assigns a local trunk line for use by the unit, it designates this line by application of ground to one of the trunk conductors, in this case conductor 229, connected to the selector magnets associated with the line in the various primary relay units. The magnets for all units having calls for the particular intermediate relay group to which the trunk line extends are accordingly energized.

Each of the selector magnets controls a multiple contact line switch LS operable to connect the bus circuit of the associated trunk line with the transmitting switches TS of the primary relay unit. In the preferred form illustrated in Fig. 12, the switches LS are arranged for mechanical actuation, the selector magnets controlling latches which normally hold the switches open. When a magnet is energized the associated switch is released for closure at the proper point in the message cycle as determined by the J-cam shaft.

The switches LS are all of similar construction and a description of one will, therefore, suffice. In its preferred form as shown in Fig. 12, the switch comprises a plurality of yieldable contact arms 231 tending to move into engagement with stationary contact plates 232, the arms and plates being anchored at one end in an insulating block 233 mounted between rigid uprights 234 forming part of the framework of the relay unit. Each contact arm 231 is provided with a terminal 235 to which is connected one of the conductors of the bus circuit of a local trunk line, these conductors being similarly connected with corresponding contact arms of other relay units of the same rank. The plates 232, however, extend through all switches LS of the unit in which they are installed and thus constitute common terminals for the transmitting switches TS and other elements of the unit. Thus, by closure of the contacts of an appropriate switch LS any local trunk line may be operatively connected with the relay unit for the transmission of message matter.

Movement of the contact arms 231 into and out of engagement with their associated plates is effected by a switch control bar 236 slidably supported for endwise movement in the uprights 234. These bars are arranged in side-by-side relation in the same horizontal plane with their ends projecting beyond the two uprights 234 as shown in Fig. 12. Rigid with each control bar is a switch actuating member 237 of insulating material having in its upper edge a series of notches 238 each presenting a shoulder for engagement of one of the contact arms. A spring 239 urges the control bar toward switch closing position, that is, to the right as viewed in Fig. 12, and when such movement is permitted the contact arms engage their respective contact plates.

The control bars 236 are normally held in a retracted or switch opening position under control of their associated selector magnets SM which are mounted on the framework of the unit adjacent the projecting ends of the control bars. In the present instance the armature of each magnet is extended to form a latch 240 engageable with an upstanding lug 241 on the associated control bar. When the magnet is deenergized a spring 242 holds the latch in engagement with the lug and thus locks the control bar in retracted position. Energization of the magnet withdraws the latch and releases the bar.

As explained above, the selector magnets SM are energized selectively under joint control of the selector relays R1, R2, R3 and the solicitor. Thus the only selector magnet energized at any time in the primary relay unit is the one associated with the trunk line assigned by the solicitor for the transfer of a message. The control bar is not permitted to advance, however, when the selecting magnet is initially energized, but is held in retracted position until the J-cam shaft moves out of the No. 2 rest position in the second part of the message cycle. The cam shaft controls the advance of the control bar through the medium of a fluted rock shaft 446' extending transversely below the entire group of control bars and having a shoulder interposed in the path of a shoulder 244 formed in the under-side of each of the switch engaging members 237. At the proper point in the message cycle the shaft 446' is rocked by a cam (not shown) on the J-cam shaft, thus freeing the released control bar for advance to switch closing position.

Movement of the J-cam shaft from the No. 2 rest position is initiated by the time assigner PT which energizes a test magnet 253' (Fig. 8) to withdraw the No. 2 detent 249' from the path of the J-clutch finger 242'. The time assigner releases the J-cam shaft of only one unit at a time so that seizure of an assigned trunk line by more than one relay unit is effectually prevented even though the corresponding selector magnets of a plurality of units may be in a position to be energized due to the presence of calls awaiting transmission to the same group of intermediate units. In this way the local trunk line assigned by the solicitor is associated individually with a particular primary relay unit for the transfer of a message stored therein.

Automatic testing.—In its movement from the No. 2 rest position to the No. 3 rest position, the J-cam shaft automatically transmits predetermined signal combinations over the seized trunk line to test the operativeness of the apparatus involved in the connection. In the exemplary system, two test signals are transmitted consisting, in this instance, of a "space" signal followed by a "blank" signal. The space signal consists of five current impulses, one in each of the five intervals of the signals while the blank signal is represented by five no current intervals in accordance with the usual telegraphic code.

The means for transmitting the test signals as herein shown comprises a series of normally open

switches TSS (Figs. 9 and 21) hereinafter called the "test signal switches," adapted to be closed momentarily by a cam 246 on the J-cam shaft 232'. The cam is timed to close the switches upon seizure of the local trunk line, thereby connecting negative battery to all five of the transmitting conductors of the local trunk line simultaneously. The switches TSS are opened in the next link cycle to disconnect the battery from the line conductors, thus transmitting a blank signal, the latter signal being completed just before the cam shaft reaches the No. 3 rest position. During the transmission of these signals the cam 246 opens a switch 245 in series with the transmitting switches TS to prevent transmission of the signal combination set up on the link positioned at the transmitting control point in engagement with the transfingers.

If the test signals transmitted as above explained are not properly received at the intermediate relay unit, a trouble magnet TM (Figs. 8 and 21) remains deenergized and the No. 3 detent 201 stops the J-cam shaft in the No. 3 rest position, that is, in the "trouble position." The attendant or supervisor is notified of this condition by operation of a suitable signal. For this purpose the J-cam shaft is provided with a cam 247 (Fig. 9) having a lobe positioned to close a switch 248 and thereby complete a circuit by way of a conductor 249 for a signal lamp 250 (Fig. 30) at the supervisory switchboard. There is one such lamp for each relay unit of the exchange so that the attendant may readily identify the particular unit in trouble and take the necessary steps to clear the same.

When the test signals are properly recorded at the intermediate unit, signal checking mechanism, to be described hereinafter, returns a signal designated the "O. K. signal" over a conductor 251 of the trunk line to energize the trouble magnet TM and withdraw the No. 3 detent. As this latch withdrawal ordinarily occurs immediately upon the transmission of the last test signal, movement of the cam shaft is substantially continuous through the No. 3 rest position to the No. 4 rest position, the latter being the transmitting position of the cam shaft. The switch 248 is closed momentarily as the cam shaft passes the No. 3 rest position and signal lamp 250 flashes to indicate that a connection has been established without trouble.

As the J-cam shaft moves into the No. 4 rest position, the cam 246 permits switch 245 to close, thereby connecting the transmitting switches to battery through a commutating switch CS (Figs. 7 and 21). The latter switch is actuated in each link cycle by a cam 252 on the constantly driven shaft 274', the cam being timed to close the switch just after the transmitting switches have been closed and to open the same just before the transmitting switches are opened. Thus the commutating switch assumes the burden of making and breaking the signal transfer circuits relieving the relatively light chain operated transmitting switches of this duty.

The J-cam shaft also withdraws the latch L9 (Fig. 7) from the path of the floating lever FL9 whereby the detent setter 272' is set for disengaging the chain advance clutch 260' as described in the prior application. Withdrawal of the latch and disengagement of the clutch occur in successive link cycles so that closure of the commutating switch in the first of these cycles is effective to transmit the signal combination on the chain link which is stopped at the transmitting control point. This is the first address signal following the class-of-message signal and it is received and recorded at the intermediate relay unit in the usual way. Thereafter, the storage chain is advanced, link by link, past the control point to operate the transmitting switches selectively and thus transmit succeeding signals of the message.

In case a full storage condition occurs at the intermediate relay unit to which the message is being transferred, certain mechanism at that unit applies ground to conductor 255 of the local trunk line (Figs. 21 and 22) to energize full storage stop magnet 545' (Figs. 7 and 10) at the primary relay unit. This magnet withdraws the latch L9 from the path of floating lever FL9 and the latter interrupts the advance of the storage chain through the transmitting control point as hereinbefore explained. When the full storage condition is relieved, magnet 545' is deenergized and the advance of the chain is resumed.

Means is provided for preventing full storage stop if the full storage condition occurs substantially at the end of a message but before the three blank links representing the end-of-message signal have been presented to the feeler CF2. This means, as herein shown, includes a normally closed switch 256 (Fig. 21) connected in series with the full storage stop magnet 545' and adapted to be opened by the feeler bar 195 as sooon as the first blank link is presented to the feeler shoe sections 193. Thus, when the full storage stop signal is received as any of the last three signals of the message is being transmitted, the circuit of the full storage stop magnet is opened and chain advance is interrupted in the usual way by the feeler under control of the blank links representing the end-of-message signal. The end-of-message signal is automatically reinserted in the message at the receiving intermediate unit under control of the feeler CF1 of that unit when the full storage condition is relieved.

A full storage condition at the primary unit is automatically taken care of by the loop indicator of the unit which is similar in all respects to that of the basic relay unit disclosed in the prior application.

In this instance the loop indicator arm 530' (Fig. 17a) actuates a switch 257 to open the line from the subscriber's station and it closes a switch 258 to operate a signal at the supervisory switchboard. The opening of the line circuit locks out the transmitter at the subscriber's station in well-known manner so that no signals can be sent out until the relay unit is again in condition to receive them. Closure of switch 258 completes a circuit from negative battery, conductor 259, signal lamp 260 (Fig. 30), to ground. This signal lamp is located at the supervisory switchboard together with other similar lamps for the other relay units so that the attendant may readily identify a unit in which the full storage capacity has been reached and take the necessary steps to relieve the unit.

Intermediate relay units

In general.—The intermediate relay units IR are generally similar to the primary relay units hereinbefore described except that they are provided with recorders arranged for the reception of signals transmitted on the simultaneous system of transmission. Certain other modifications have been incorporated in these units to take care of additional functions required in the

efficient operation of a complete automatic telegraph system. These modifications will be described hereinafter in connection with the particular part of the unit to which they apply.

The recorder.—Referring to Fig. 13, the recorders for all of the intermediate units are alike and are structurally similar to the basic relay unit disclosed in the prior application. Each recorder includes a series of five signal responsive electromagnets 156' which, through the medium of latches L1 to L5 and floating levers FL1 to FL5, actuate pin pushers 154' to set the pins in the chain link at the recording control point. The forward movement of any pin pusher initiates the advance of the chain in well-known manner through the engagement of an upstanding lug 197' on the pusher with a bail 196' carried by a rock shaft 134'. This shaft is operably connected by a crank arm 192' and link 193' with a detent setter 139' which engages the chain advance clutch (not shown).

It will be recalled that upon seizure of the local trunk line of the primary unit, two test signals were automatically transmitted over the trunk line. The first or "space" signal, consists of five current impulses energizing all of the line magnets 156' thereby causing all pins in the link at the control point to be pushed. The chain advance is initiated and, in the next link cycle, the second test signal or "blank" consisting of five no current impulses is received. In this case none of the line magnets become energized, hence none of the pins of the second link is pushed.

The test signals recorded in the above manner are checked by signal checking mechanism including a double feeler mechanism CF3 hereinafter called the "all-no" feeler. As will be seen by reference to Fig. 14, this feeler mechanism comprises a pair of independently movable slides 300 and 301 therein, shown as flat, generally L-shaped members arranged to define a rectangular central opening adapted to enclose the storage chain and chain guides. The slides are supported in any convenient manner for endwise movement transversely of the chain and in a plane parallel to the rows of pins. In the present instance, the slides are located in a plane above the pin pushers 154' substantially midway between the first two links of the chain above the link at the recording control point.

Fixed to the respective slides, at the front and rear of the chain, are two groups of feeler shoes 302 and 303. Each group consists of five shoes, one for each row of pins in the chain. The shoes are formed on one vertical edge with a cam surface 304 (Fig. 14) over which the pins of the chain are adapted to ride. As will be seen by reference to Fig. 14, shoes 302 and 303 are secured respectively to the upper and lower sides of their associated slides with their active cam surfaces spaced apart by a distance equal to the pitch of the chain. The latter shoes are similarly spaced above the recording control point, thus enabling them to cooperate with the pins of the last link to advance beyond the control point while shoes 302 simultaneously cooperate with the pins of the preceding link.

The shoes 302 are set outwardly from the chain so as to engage only non-pushed pins and shoes 303 are set inwardly from the chain to engage only pushed pins. A spring 305 acting on each slide urges the same in a direction to move the shoes into engagement with the chain pins and if any shoe engages a pin, movement of the slide is blocked. However, when the pair of links on which the test signals are recorded are set in sequence with a space signal (all pins pushed) and a blank signal (no pins pushed) all shoes clear the pins and the both slides are permitted to advance. In this advance the slide 300 closes a switch 306 and the slide 301 closes a switch 307 connected in series circuit with the trunk conductor 251 (Figs. 14 and 22). Closure of these switches results in the connection of ground potential to the trunk conductor and constitutes the "O. K." signal for energizing the trouble magnet TM of the primary relay unit as hereinbefore described. If, on the other hand, the test signals are improperly recorded as evidenced by one or more non-pushed pins in the first link or one or more pushed pins in the second link, one or both sets of feeler shoes is blocked, switch 306 or 307, or both, remains open, and the primary relay unit is stopped in the trouble position.

When the test signals are properly received and signal transmission is initiated as above described, the transfer of the remaining signals of the message takes place at the rate of 3,600 signals per minute until the complete message has been recorded on the storage chain at the intermediate relay unit. The chain links withdrawn from the supply section of the unit and advanced to the recording control point are counted by a mechanism LI (Fig. 17) conveniently called the loop indicator which also counts the number of blank links coming into this section from the transmitter. This mechanism provides an indication of the number of blank links available at the recorder and, when the supply is exhausted, that is, when the full storage capacity of the unit is reached, it closes a switch 540' (Fig. 22) which corresponds to switch 258 (Fig. 17a) to apply ground to trunk line conductor 255 to energize the full storage stop magnet of the primary relay unit as previously described. This mechanism also acts mechanically to stop the chain advance at the recorder as described in the prior application.

The full storage condition is indicated by the lighting of a signal lamp 308 at the switchboard, there being one such lamp for each intermediate relay unit in the exchange. Each lamp is connected by means of a conductor 309 with conductor 255 of the local trunk line terminating at the associated relay unit. Accordingly, closure of any full storage stop switch 540' is effective to complete a circuit for its associated signal lamp. The attendant is thus enabled to quickly locate the relay unit requiring attention.

Unless interrupted in the above manner, chain advance continues until stopped by the end-of-message signal feeler CF1a (Figs. 13 and 14) upon appearance of the end-of-message signal consisting of three blank links, the feeler then acting to disengage the chain advance clutch (corresponding to clutch 71 of the primary relay unit). The feeler CF1a, as herein shown, comprises a set of five shoes 291, similar to the shoes 303, but having a cam surface 292 extending over the two adjacent chain links. These shoes are mounted on a sliding bar 293 and are yieldably urged into the path of the chain pins by a spring 294 acting on the bar. As shown in Fig. 15, the bar 293 is arranged to engage a shiftable member 295 operatively connected to one arm of a bell crank 223' (Fig. 15) pivoted to rock about a vertical axis. The other arm of the bell crank is connected by a link 224' and a crank and knuckle

joint to a crank arm 225' fast on a horizontal rock shaft 226' which carries a control finger 222' for actuating a latch L6. The latch L6 cooperates with one end of a floating lever FL6 mounted to oscillate with the floating levers FL1 to FL5 and operative through a push bar 199' to rock the detent setter positioning shaft 194' (Fig. 13).

In order to prevent the feeler CF1a from interrupting the chain advance before the first test signal is presented thereto, a mechanical connection is provided whereby the feeler bar 293 is shifted to operated position by the slide 301 as the pins representing that signal engage the feeler shoes 303. To this end, the slide 301 is formed with an upstanding lug 296 engaging an arm 297 projecting laterally from the bar. The arrangement is such that, subject to the other controls herein mentioned, the chain advance clutch is engaged as long as the feeler CF1a or slide 301 of the feeler CF3 is shifted out of normal rest position by the passage of links having one or more pushed pins. Upon return of the feelers to normal position, the clutch is disengaged to interrupt chain advance.

The feeler CF1a also operates at the end of each message to mechanically close a switch 311 (Figs. 15 and 22) hereinafter called the availability switch to indicate to the associated solicitor that the intermediate unit is available for other messages. Closure of this switch is effected, in the present instance, through the medium of a plunger 312 guided for endwise movement in a cross member 313 of the recorder frame and having at its lower end a switch engaging member 314 of insulating material engageable with the movable contact member of the switch. The upper end of the plunger is arranged in trip-free operative relation to one arm of a bell crank 315, the other arm of which is connected by a knuckle joint with the crank arm 225' on the rock shaft 226'. When the shaft is rocked at the end of the message as above described, the plunger is depressed to close the switch. Thereafter, until the relay unit is seized for another message, the switch is held closed by a magnet 316 energized under control of the solicitor as will be explained presently.

As the links on which the signals have been recorded, as above described, are run into the storage section of the relay unit, they are counted by the storage indicator mechanism in the usual way. When one or more links with pushed pins are delivered to the storage section of the relay unit, the storage indicator initiates chain advance at the transmitter. As the first link of the message, in this case the link set with the first test signal combination, approaches the transmitting control point, it engages the message feeler CF2 (Fig. 13) and the latter in known manner releases the J-cam shaft for movement from the No. 1 rest position to the No. 2 rest position, that is, in the first step of the message cycle. In this movement the shaft acting through a cam interrupts the chain advance, the cam being timed to stop the chain after the two links set with the test signals have passed the transmitting control point and with the third link set with the first address signal of the message located at that point. The transmitter is now in condition to select a local trunk line leading toward the destination indicated by the address signal.

The transmitter.—The transmitters of the intermediate units are like those of the basic relay unit in that each has a single set of transfingers 411' (Fig. 13) arranged to control a permutational selector mechanism in addition to controlling transmitting switches TSa (Fig. 22) for sending signal impulses over a local trunk line to the relay unit of the next rank. As herein shown, the transfingers 411' (Fig. 13) each comprises an L-shaped portion pivotally mounted between vertically spaced plates 412' to swing on closely spaced vertical axes. Each transfinger carries a shoe 413' with oppositely inclined leading and trailing cam surfaces intersecting at the transmitting control point. When a non-pushed pin approaches the control point, it engages the leading surface of the associated shoe and cams the same out of the path of movement of the pin. Thus the transfingers are selectively operated in accordance with the setting of the pins in the chain.

Each of the transfingers 411' is formed with a tail-piece 417' which carries the movable contact of one of the transmitting switches TSa and which additionally serves to control setting elements of a transfer device to govern the operation of the selector mechanism.

Selector mechanism.—The function of this mechanism is to select a transmission path or a group of transmission paths leading to the particular terminal unit or units designated by the first directing signal combination presented at the transmitting control point. In general, the selector mechanism is similar to the line selector shown and described in the prior application modified in certain respects to permit selection of a group of transmission paths and then to seize a particular one of the paths under control of traffic distributing mechanism such as a solicitor.

Referring to Fig. 16, the selector mechanism in its preferred form comprises a group of code bars 435' and a pair of auxiliary code bars 317 and 318 arranged in closely spaced parallel relation for endwise movement between an active and an inactive position. Selective positioning of the code bars 435' is effected in accordance with the combination set up on the transfingers by the address link at the recording position through the medium of a transfer mechanism exactly like that shown and described in the prior application to which reference may be had. As herein shown, there are five of the code bars 436' and since they are capable of occupying either of two positions they may be set in thirty-one different combinations by moving one or more of the bars from its inactive to its active position. The code bars 317 and 318 are positioned under control of selector magnets SM10 and SM11 (Figs. 16, 22, 25 and 28).

Cooperating with the code bars 436' are a set of combination bars 437' hereinafter called line selector bars, one for each trunk line accessible to the intermediate relay unit. The selector bars are mounted for endwise movement above and transversely of the code bars and each is provided adjacent one end with depending wards 444' adapted to cooperate with notches in the upper edges of the code bars 436'. These notches are arranged in well-known manner so that for each permutational setting of the code bars a transverse groove is formed across the entire group of bars through which the wards of a selector bar may move. When the code bar setting represents a particular transmission path as, for example, one leading to a terminal unit associated with a subscriber's line, only one selector bar is

released for movement. However, if the code bar setting represents a group of transmission paths such as those leading to the terminal units of a group of trunk lines extending to another exchange of the system, the notches of the code bars are duplicated so as to release a plurality of selector bars, one for each terminal unit in the group.

The latter selector bars which may be conveniently called group selector bars are formed with additional wards arranged for cooperation with the code bars 317 and 318, the arrangement being such that only one of the selector bars is allowed to advance through its full stroke as determined by the particular code bar operated. This advance occurs on movement of the J-cam shaft from its No. 2 rest position.

Each of the selector bars 437' controls a multiple contact line switch ILS, there being one such switch for each secondary trunk line STL accessible to the intermediate units. Five of these secondary trunk lines are shown by way of illustration leading to the terminal relay units TR_1 to TR_5 respectively, as indicated by the numerals 1 to 5 suffixed to the general reference character STL. The line switches for these trunk lines are similarly identified by the numerals 1 to 5 suffixed to the reference character ILS (see Figs. 22, 25 and 28).

The line switches ILS are all of similar construction and, as shown in Fig. 16, each comprises a plurality of yieldable contact arms 326 tending to move into engagement with stationary contact plates 327. The arms and plates are anchored at their upper ends in an insulating block 328 (Fig. 13) mounted between rigid uprights 329 which form a part of the framework of the relay unit. Each contact arm 326 is provided with a terminal 330 to which is connected one of the conductors of the intermediate bus circuits IB1 to IB5 which terminate at switch terminals BJ of suitable jacks JK (Fig. 31) at the switchboard SB. The secondary trunk lines STL terminate in jack switch terminals TJ at the switchboard which cooperate with the first-mentioned switch terminals and connect the trunk lines with the respective bus circuits except when a cord plug is inserted in the jack as will appear presently. In the present instance all of the trunk lines are accessible to all of the intermediate relay units of the exchange, hence the conductors of the bus circuits are connected with corresponding terminals of the switches in each of the intermediate relay units. The plates 327, like plates 232 of the primary units, extend through all switches ILS of the unit in which they are installed, and constitute common terminals for the transmitting switches TS_a and other elements of the unit. Accordingly, closure of an appropriate switch ILS is effective to operatively connect a trunk line with the unit for the transmission of message matter.

Movement of the contact arms 326 into and out of engagement with their associated contact plates is controlled by the combination bars 437' through the medium of individual switch actuating members 331 of insulating material rigid with each selector bar. Each actuating member has formed along its upper edge a series of notches 332 each presenting a shoulder for engagement with one of the contact arms. A notch in the lower edge of the member presents a shoulder 333 for engagement with a fluted rock shaft 446' similar to the fluted rock shaft hereinbefore described. The shaft normally holds the combination bars in retracted position as shown in Fig. 16 whereby the contacts of the switches ILS are held open. When the shaft is rocked out of normal position, individual actuating springs move the control bars into operative relation to the code bars which block all but the selected combination bar or bars.

As is the case in the prior application, the shaft 446' is rocked in a manner so as to permit movement of a released combination bar in two steps. Rocking of the shaft is effected through the medium of a cam on the J-cam shaft which is timed so that the first step of the selected combination bar or bars takes place upon movement of the J-cam shaft from its No. 1 to its No. 2 rest position, this movement being timed with respect to the setting of the code bars so as to follow immediately thereafter.

A selected one of the regular combination bars such as the one associated with the trunk line leading to the terminal unit TR_2 associated with the line from subscriber's station Q_a (Fig. 1), on moving through its first step, closes a test contact 335 (Fig. 22) to complete a starting circuit for the time assigner ST_1 of the relay unit group by way of bus conductor 336, a timing switch 337 closed by a cam 337_a (Fig. 16^a) on the J-cam shaft, and a conductor 338. If the terminal unit is not busy and is otherwise in condition to receive, there will be battery potential on bus conductor 336. The time assigner is thus started and, in due time, applies a ground potential to starting conductor or pilot wire 338_a to energize the test magnet 253' (Figs. 8 and 22) and thus release the J-cam shaft for movement from the No. 2 to the No. 3 rest position.

When the code bars are set to release the group selector bars, for example, those associated with the line switches for the trunk lines leading to terminal units transmitting to exchange B, all of these bars advance in their first step on initial movement of the shaft 446' as above explained. In this movement, the selector bar controlled by code bar 318 closes test contacts 335_a to prepare a starting circuit for the time assigner over trunk line and bus conductor 336_a. In addition, contacts 339_a and 339_b of the respective line switches are closed to connect selector magnets SM10 and SM11 to conductors 340_a and 340_b of the proper bus circuits.

The particular one of the terminal units to receive the message is determined by the solicitor SS associated with these units which causes a battery potential to be applied to either conductor 340_a or 340_b as the case may be. Assuming that the first-mentioned conductor is selected, magnet SM11 is energized to release the code bar 318 which advances upon the timed withdrawal of a bail 341 by a cam 341_a on the J-cam shaft. Magnet SM10 remains deenergized, hence code bar 317 which it controls is held in retracted position. The advance of the bar 318 releases the selector bar for the trunk line STL3 while the selector bar for the trunk line STL4 is blocked by the latched code bar 317.

The selected bar 437', whether a regular or a group bar, is permitted to advance in its second step as the J-cam shaft starts its movement from No. 2 rest position. In this advance, all switch contacts of the associated line switch are closed thereby completing a connection with the seized trunk line. At the same time, the selector magnet circuits for both latch magnets are opened to prevent accidental seizure of the second trunk line during the transmission of the message and

to reduce the load on the solicitor contacts. This is accomplished by means of a set of switches **341** (Figs. 16ª and 22) actuated by a cam **342** on the J-cam shaft. On further movement of the cam shaft, test signals similar to those transmitted by the primary units are sent over the seized trunk line by a test signal switch TSS_a actuated by a cam **343** on the J-cam shaft. In the transmission of these signals, a set of switches **344** in series with the transmitting switches TS_a are opened to prevent interference with signal transmission.

If the test signals are not correctly received and recorded, the J-cam shaft is stopped in the trouble position. In this position a cam **345** closes switch **346** to complete a circuit by way of conductor **347** for lighting a trouble lamp **348** (Fig. 30) at the supervisory switchboard. In this position of the cam shaft, cam **345** also opens a switch **350** in series with the solicitor plunger magnet PM and the availability switch **311** to prevent seizure of the relay unit until the trouble condition is cleared.

When the test signals are correctly received and recorded at the terminal unit, ground is returned over conductor **351** of the trunk line to energize trouble magnet **352** of the intermediate unit and thus prevent stopping of the J-cam shaft in its movement to the No. 4 rest position.

In its movement from No. 3 to the No. 4 position, the J-cam shaft through the medium of a cam **353** (Fig. 16ª) closes a switch **354** to transmit a class-of-message signal over the seized trunk line. As will be seen by reference to Figs. 22, 25 and 28, the switches **354** for the intermediate relay units of the different groups are connected to different trunk conductors so that the signal sent out is distinctive of the group. In this instance it corresponds to the class-of-message signal originally incorporated in the message. The reinsertion of the class-of-message signal is for the purpose of properly directing messages through other exchanges. In the case of local messages, the signal is reproduced at the receiving station to indicate to the receiving subscriber the manner in which the message was forwarded.

Simultaneously with the transmission of the class-of-message signal, the J-cam shaft initiates advance of the chain past the transmitting control point in the manner described in connection with the primary relay unit transmitter. This operation is timed so that the first message link, that is, the link set with the first address signal, is moved out of engagement with the transfingers before the series of switches **344** are closed. The first address signal, having served its purpose of directing the course of the message, is thus discarded. Succeeding signal combinations are transmitted in the usual way by the transmitting switches TS_a in cooperation with commutating switch CS_a. In the event of a full storage condition at the terminal unit to which the message is being transferred, a ground potential returned over the bus conductor **355** of the trunk line in use energizes full storage stop magnet **545'** to stop the chain and thus interrupt transmission until the terminal unit is again in condition to receive.

At the end of the message, feeler $CF2_a$ releases the J-cam shaft for movement from the No. 4 to the No. 1 rest position. In this movement the cam shaft interrupts chain advance and rocks the shaft **446'** to return all of the selector bars to normal position. The trunk line to the seized terminal unit is thereby released for other messages.

Signal counting mechanism.—Reference has been made heretofore to the mechanism for interrupting transmission to the intermediate relay unit when the full storage capacity of the unit is reached. This mechanism conveniently called the "loop indicator" is similar to the loop indicator shown and described in the prior application and it performs exactly the same functions. Briefly, it comprises a shaft **501'** (Fig. 17) arranged to be driven differentially from the recorder and the transmitter through a spur gear differential **502'**. One terminal gear **504'** of the differential is pinned to the shaft **176'** which carries the sprockets **53'** for advancing the storage chain through the recorder loop **6'**. The other terminal gear **505'** of the differential is driven by a cross shaft **507'** from the shaft **269'** which carries the sprockets for advancing the chain through the transmitter loop **7'**. The arrangement is such that the shaft **501'** is rotated in one direction when the recorder alone is operating and in the opposite direction when the transmitter alone is operating. When the recorder and transmitter are operating simultaneously the shaft remains stationary as in this instance chain advance is effected at the same rate in both the transmitter and recorder loops.

Threaded on the shaft **501'** is a rider **500'** which is held against rotation by a depending flange **361** slidable in a groove **362** in a stationary member **363** forming a part of the framework of the unit. Due to the threaded connection between the shaft and the rider, the latter is shifted back and forth in accordance with the direction of rotation of the shaft. In the particular embodiment illustrated, the arrangement is such that the rider moves to the left (as viewed in Fig. 17) when the transmitter alone is operating and thus feeding blank links into the supply section of the storage mechanism. As the last message signal leaves the storage section, the rider is stopped at the "zero" position shown in the drawings, thus indicating that substantially all of the chain links are available for use by the recorder.

On the other hand, when the recorder alone is operating and withdrawing blank links from the supply section, the rider **500'** is moved gradually to the right, its limit of movement in this direction being reached simultaneously with the exhaustion of the supply of blank links in the supply section.

Since the links withdrawn from the supply section are run into the storage section after signal combinations are recorded thereon and are held there until such signals are transmitted, the position of the rider not only indicates the number of links available in the supply section, but it also indicates the amount of message matter in storage or, in other words, the storage level of the relay unit. It is, therefore, convenient to utilize the loop indicator for actuating a part of the primary distributing mechanism for distributing traffic uniformly to the intermediate units of the group in which this particular unit is included.

Primary distributing mechanism

To reduce to a minimum the average time during which any message will be held in storage in an intermediate relay unit, the message should be sent to that unit which has the least message matter in storage at the time when the message becomes ready for transmission to the intermediate units. The primary distributing mechanism herein disclosed has been devised to ap-

proximate this ideal distribution and operates to render any intermediate relay unit in its group unavailable for further reception of messages in the event that its storage exceeds by a predetermined amount the storage in the other relay units of the group. The permissible variation in storage levels, hereinafter termed the indicated levels, may be set at any desired figure. In the exemplary system the indicated levels are arranged in storage steps of 500 links each.

In general, the primary distributing mechanism acts to route messages to relay units whose storage level is below the indicated level of the entire group of relay units. Thus, when all relay units in the group are empty, any one can be used, but when all but one has message matter in storage, only that one can receive the next message. The same applies to other 500 link indicated levels up to the 2,000 link limit above which the relay units are ordinarily not available, although they are customarily provided with additional storage capacity (usually 1,000 links) so that a maximum length message can be recorded if started when the relay unit is near the 2,000 level.

The primary distributing mechanism, as herein shown, comprises five separate equipment organizations which, although structurally independent, are electrically interconnected to operate as a unitary structure. These include a level switch mechanism for each relay unit in the group, a level switcher LEV common to the several mechanisms, the solicitor PS for effecting actual assignment of the relay units in cooperaiton with the level switch mechanisms and the level switcher, a level shunt control mechanism for temporarily suspending operation of the level switcher under emergency conditions, and the time assigner PT for controlling the order of connection of the primary relay units. The level switch mechanisms are structurally independent and each is desirably incorporated in its associated relay unit. These mechanisms act to control the level switcher LEV as will be explained hereinafter and in cooperation with the switcher control the operation of the solicitor. The latter includes a mechanically actuated selecting element 369 (Fig. 19) for each intermediate relay unit, hereinafter termed a plunger, for each relay unit, and through the operation of these elements the units are selected and assigned for reception of messages. The operation of the plungers is controlled in part by plunger magnets PM which are likewise individual to the several relay units. The time assigners (Fig. 20) are structurally similar to the solicitors each including a mechanically actuated element or plunger 370 controlled in part by a plunger magnet TPM individual to the respective primary relay units.

Having in mind the general arrangement of the distributing mechanism as above set forth, the various equipment organizations will now be described in the order in which they are mentioned above.

Level switch mechanism.—Referring to Figs. 17, 22, 25 and 28, the level switch mechanism as installed in each intermediate relay unit comprises five groups of switches 371, 372, 373, 374 and 375, one for the "zero" storage level and four for the other storage levels. As stated above, the indicated levels at which the selective assignment of the relay units are effected have been arbitrarily established at 500, 1,000, 1,500 and 2,000 links in storage. It will be understood, however, that these numbers are entirely a matter of choice and that the number of levels utilized may be increased or decreased, if desired, or the storage condition represented by any or all the levels may be changed to suit the particular operating conditions obtaining. Each of the first four switch groups consists of three switches identified respectively by the characters *a*, *b* and *c* suffixed to the group reference number. The fifth switch group comprises a single switch corresponding to the *a* switches of the other groups.

Referring to Fig. 17, the movable and stationary members of the switches 371—375 in the form of resilient metal strips are mounted on an elongated segmental supporting member 376 of insulating material carried between brackets 377 rigid with the framework of the relay unit. The supporting member is disposed generally parallel to the loop indicator shaft and the switch groups are arranged in side-by-side relation so as to align respectively with the rider 500' at the different storage levels, the switches of each group being located in the same vertical plane.

In the preferred form illustrated, the *a* and *b* switches are mounted on one side of the support 376 and the *c* switches are mounted on the opposite side of the support for cooperation with a common switch actuating member in the form of an arm 378 loosely mounted on a horizontal shaft 379 to swing in the vertical plane of the switches. Fitted on the upper end of the arm between the *a* and *c* switches is a T-shaped head 380 of insulating material adapted to engage the movable members of these switches alternately. A pin 381 of insulating material affixed to one edge of the arm 378 adjacent the head 380 is arranged to coact with the movable member of the *b* switch.

The switch actuating arms 378 are normally held in a retracted or "down" position by individual springs 382 and in this position act to close the associated *a* and *b* switches. Upon movement of a switch arm to its operated or "up" position the switches *a* and *b* open and the *c* switch is closed. Operation of the switch arms is effected as an incident to the movement of the rider 500' through a point corresponding to the level represented by the switch group. Thus, as the rider moves upwardly, the switch arms are operated in succession as the rider passes the 0, 500, 1,000, 1,500 and 2,000 levels. On the return movement of the rider, the switch arms are returned to their "down" positions in the reverse order.

The mechanism for operating the switch arms is so arranged that movement of an arm from its down to its up position, or vice versa, is effected in less than one link cycle and in timed relation with the cycle so as to avoid any possibility of interference with the proper functioning of the distributing mechanism. For this purpose a switch arm engaging lever in the form of a bell crank 383 is pivoted on a bracket 384 projecting laterally from the rider 500', the upper end of the lever being positioned for engagement with the tips of the switch arms 378 as the rider moves along the loop indicator shaft 501'. The lever is rocked about its pivot in timed relation to the link cycle through the medium of a cam 385 fast on the end of the loop indicator shaft 501'. For this purpose, the cam is formed with a sloping portion 386 which at the proper point in the cycle engages a follower roller 387 carried on a crank arm 388 fast on a rock shaft 389 which extends generally parallel to the loop indicator shaft. Fast on this shaft is a collar 390 having

an elongated radially projecting flange **391** slidably engaging in a slot in the lower end of the lever **383**. The arrangement is such that an operative connection between the flange and the lever is maintained throughout the entire range of movement of the rider **500'** whereby the lever may be rocked between active and inactive positions by the rotation of the cam. A spring **392** acting on a crank arm **393** fast on the rock shaft normally maintains the lever in its inactive position.

As the cam **385** is rotated with the loop indicator shaft which drives the rider **500'**, the operation of the lever **383** is automatically timed with the movements of the rider. In the present instance the arrangement is such that as the rider passes the zero level, the lever **383** is rocked to move the first switch arm **378** to its operated or up position, thereby opening the switches **371a** and **371b** and closing the switch **371c**. As the rider passes the 500 level the switch arm **378** located at that level is operated to open the associated switches **372a** and **372b** and close the switch **372c**. The same sequence of operation takes place as the rider passes the 1,000 and 1,500 levels. At the 2,000 level the fifth switch arm is operated to open the switch **375a**. As long as the rider is above the position in which a switch arm is operated, the arm is held in its up position through the medium of an elongated bar **394** secured to the rider **500'** with its rear edge positioned to engage the tip of the arm. In the up movement of the rider, that is, movement to the right as viewed in Fig. 17, the edge of the plate engages the tip of the switch arm before the lever **383** is withdrawn.

On reverse movement of the rider, the switch arms are returned to their down positions in succession through the action of lever **383**, cam **385** acting in reverse manner. Thus, as the holding bar **394** is withdrawn from the path of each switch arm, the arm is engaged by the lever **383** which is in its forward position at this time due to the action of the cam **385**. As the cam follower rides down the inclined surface of the cam, the lever is returned to its normal position, thus allowing the switch arm to move back to its down position without shock or jar.

A level switch mechanism such as that described is provided for each of the intermediate relay units. Certain of the switches of each mechanism are connected in series to control the operation of the level switcher, which, through the medium of other of the level switches and switches actuated by the switcher govern the operation of the solicitor to determine automatically the order in which the relay units are assigned for the reception of messages.

Level switcher.—The function of the level switcher LEV is to prepare marking circuits for the relay units of its associated group in accordance with the storage levels of the respective units. More particularly, the level switcher performs switching operations whereby non-busy relay units are marked available for the reception of messages in preferential order as determined by the storage levels of the units. This is done by closing the circuits for the solicitor plunger magnets of the relay units whose storage level is below the indicated level of the switcher. Thus, when certain of the relay units of the group are at or above the 500 storage level and others are below that level, the said other units are given preference until they too reach the 500 level. When this occurs the switcher is automatically shifted to the next higher indicated level to condition it for determining preference of the relay units until all reach or pass the 1,000 storage level. This preferential selection is carried out in the same manner at each indicated level. However, when the storage level of one or more units falls below the indicated level in which the switcher is operating, the latter is immediately returned to a lower indicated level to pick up the unit or units with depleted storage.

Level switching circuits.—In carrying out the above operations, the level switcher is equipped with a plurality of sets of electrical switches arranged for actuation in a predetermined sequence by suitable cams carried on a cam shaft **401** (Figs. 18 and 20a) having a plurality of rest positions, each of which represents an indicated level. These indicated levels correspond to the storage of the relay units and in this instance are identified respectively as the 0, 500, 1,000, 1,500 and 2,000 indicated levels.

One of the sets of switches above referred to comprises four groups of switches, that is, one group for each indicated level above the zero level. Each group includes a switch for each relay unit served by the level switcher. In the system illustrated, there are three intermediate relay units associated with each level switcher, hence three switches are provided in each group. For convenience of identification, these switches are designated by a common reference character K preceded by the numerals 1, 2 and 3 to indicate the particular relay unit to which they are connected and followed by a suffix 5, 10, 15 or 20 to indicate that the switch is assigned to the 500, 1,000, 1,500 or 2,000 indicated level as the case may be. In Figs. 22, 25 and 28, the switches are shown grouped in accordance with their circuit relationship and the individual switches are designated with their level identifying suffixes. The physical grouping of the switches is shown in Fig. 18, while their arrangement with respect to the cam shaft is shown in Fig. 20a.

Referring to Figs. 18 and 20a, it will be observed that the four groups of K switches are arranged around the periphery of a cam **402** fast on the cam shaft **401**. These switches are of the normally open type and are adapted to be closed in succession as the cam shaft advances from its normal rest position, which may conveniently be called the "up" movement. Closure of the switches is effected in this instance by individual actuating members, each comprising a push rod **403** having a squared end portion **404** guided for endwise movement in a rigid member of the frame **405**. Each push rod carries on its lower end a cam follower roller **406** engageable with the periphery of the cam **402**. A coiled compression spring **407** encircling the push rod holds the follower roller in engagement with the cam.

By reason of the position of the K switches and the contour of the cam **402**, all of the switches are in open condition when the cam shaft is in its normal rest position. Upon movement of the shaft to its second rest position, switches $1K_5$, $2K_5$ and $3K_5$ are closed. In the third rest position, switches $1K_{10}$, $2K_{10}$ and $3K_{10}$ are closed. Switches $1K_{15}$, $2K_{15}$ and $3K_{15}$ are closed in the fourth rest position, and finally switches $1K_{20}$, $2K_{20}$ and $3K_{20}$ are closed in the fifth rest position. On downward movement of the cam shaft, the switches are opened successively in reverse order.

Each of the switches $1K_5$—$1K_{20}$ is arranged with a corresponding one of the level switches **372a**—**375a** of the first intermediate relay unit in a series

circuit for the plunger magnet 1PM of that relay unit. Switches $2K_5$—$2K_{20}$ are similarly arranged with the level switches 372_a—375_a of the second primary unit in series circuit with the plunger magnet 2PM of that relay unit. Likewise, the third group of switches $3K_5$—$3K_{20}$ and switches 372_a—375_a of the third primary unit are incorporated in the circuit of the plunger magnet 3PM of the last-mentioned unit.

It will be apparent from the foregoing that the switches $1K_5$ and 372_a jointly complete one energizing circuit for the magnet 1PM, switches $1K_{10}$ and 373_a complete a second energizing circuit for the magnet, etc. As explained before, the switches 372_a—375_a are opened successively as storage in the relay unit passes the 500, 1,000, 1,500 and 2,000 levels, respectively. Accordingly, the plunger magnet for the relay unit can be energized only when the storage level of the relay is below the indicated level in which the switcher is operating. For example, when switch $1K_5$ is closed in the 500 indicated level as it will be when all of the associated relay units are above the zero storage level and at least one is still below the 500 level, plunger magnet 1PM can be energized only in the event that the switch 372_a is closed due to the presence of less than 500 links in the storage section of the first relay unit. If the number of links in storage in that unit exceeds 500 links, switch 372_a is opened, hence the plunger magnet circuit is incomplete and the relay unit is marked unavailable at the solicitor.

As the K switches are similarly interconnected with the level switches of the other relay units, it follows that the relay units are marked available in accordance with the amount of message matter stored therein. As a result, the traffic is distributed over the relay units with substantial uniformity so that each unit handles approximately the same amount of traffic. This, of course, equalizes wear of the equipment and it likewise expedites message transfer since delays, due to overloading of one unit, are effectually avoided.

Drive mechanism.—The movement of the level switcher cam shaft 401 between its several rest positions is effected by suitable power driven means controlled through the medium of control circuits including the *b* and *c* level switches of the respective relay units and switches actuated by the cam shaft itself. The power driven means may, of course, be of any suitable character. In its preferred form as shown in Fig. 18, it includes a pair of intermittently operated oppositely rotating drive shafts 411 and 412 operatively connected with the cam shaft by a spur gear differential 413, one terminal gear 414 of which is fixed to the shaft 411, and the other terminal gear 415 of which is fast on the shaft 412. The intermediate of the differential is in the form of a gear 416 which meshes with a gear 417 fast on the cam shaft.

As herein shown, the shaft 411 is arranged to be driven intermittently in steps of 120 degrees by a positively acting clutch 418 preferably of the bar type similar to the clutch 71 hereinbefore described. The driving member of this clutch is rotated continuously in a clockwise direction from a main shaft 419 driven in any suitable manner at the same speed and in synchronism with the main drive shafts of the relay unit. The drive for the clutch member in this instance comprises a gear 420 on the main shaft, an intermediate gear 421 and a gear 422 rigid with the clutch member.

The clutch 418 is provided with a control finger 423 of the usual character adapted to disengage the driving and driven elements of the clutch when blocked against rotation by a detent 424. The detent as herein shown comprises an extension of the pivoted armature of a magnet UM, hereinafter called the "up" magnet, which operates when energized to withdraw the detent and thus free the finger for engaging the clutch elements. When the magnet is deenergized, a spring 425 returns the detent to the position shown in the drawing in which it blocks the clutch finger and thereby disengages the clutch.

When the clutch 418 is engaged, the shaft 411 is rotated in a clockwise direction (as viewed in Fig. 18) and through the intermediate gearing it turns the cam shaft 401 in a counter-clockwise or "up" direction, that is, toward the higher indicated levels. The gear ratios are such that the cam shaft moves from one rest position to the next in each cycle or partial revolution of the shaft 411, the cam shaft movement in this instance being in steps of one-eighth of a revolution.

The other drive shaft for the differential, namely the shaft 412, is driven intermittently by a clutch 426 similar in all respects to the clutch 418 above described. In this instance, however, the driven clutch member is rotated in a counter-clockwise direction as its driving gear 427 meshes directly with a gear 428 on the main shaft 419. Consequently, when the clutch 426 is engaged, the shaft 412 is rotated so as to turn the cam shaft 401 in the "down" direction or toward a lower indicated level. Engagement of this clutch is effected by a magnet DM hereinafter called the "down" magnet through the medium of a spring actuated detent 429 cooperating with a control finger 430 of the clutch.

Control circuits.—The positioning of the cam shaft at the various rest positions or indicated levels is controlled by selective energization of the detent actuating magnets UM and DM in accordance with the general storage level of the associated relay units. This control is effected in the present instance by the control circuits hereinbefore referred to, of which there are a plurality for each detent magnet. The control circuits for the "up" magnet UM include the *c* switches of the several units and a group of four switches J actuated in successive switching levels by a cam 431 (Figs. 18 and 20^a) on the cam shaft 401. The control circuits for the "down" magnet DM include the *b* level switches of the several units and a group of four switches J1 also actuated by the cam 431.

In the preferred form illustrated in the drawings, the J and J1 switches are arranged around the periphery of the cam 431 and spaced apart as indicated in Fig. 20^a. For actuating these switches, the cam is formed with two lobes coacting with follower rollers 432 (Figs. 18 and 20^a) carried by push rods 433 individual to the respective switches. Like the push rods 403 previously described, the push rods 433 are formed with square shanks 434 guided for endwise movement in the frame member 405. Coiled springs 435 hold the followers in engagement with the cam.

The sequence in which the J and J1 switches are operated will be readily seen by reference to Fig. 20^a. Thus, when the cam shaft is in its normal rest position, that is, the zero indicated level, the J_0 switch is closed and all of the remaining switches are open. In the second rest position, the J_5 switch and $J1_0$ switch are closed, and the

other switches are open. In the third rest position, the J_{10} switch and the $J1_5$ switch are closed and the others are open. In the fourth rest position, the J_{15} and $J1_{10}$ switches only are closed. Finally, in the fifth rest position, the $J1_{15}$ switch alone is closed.

Referring now to Figs. 22, 25 and 28, it will be observed that the 371_c switches of the several relay units, and the J_0 switch are arranged in series circuit with the "up" magnet UM. Similarly, the 372_c, 373_c and 374_c are arranged in circuit with the J_5, J_{10} and J_{15} switches, respectively, in parallel circuits for the magnet UM. Thus, when the storage levels of all of the units initially rise above the zero level, all of the switches 371_c are closed and with switch J_0 closed as above explained, the magnet UM is energized to engage the clutch **418** and thus cause the cam shaft to be rotated in the "up" direction to the next rest position or the 500 indicated level. At this level the switch J_0 is opened to interrupt the circuit in the magnet and the switch J_5 is closed so that when all of the switches 372_c close upon the relay units reaching or passing the 500 storage level, magnet UM will again energize to initiate movement of the cam shaft to the third rest position or the 1,000 indicated level. In the same manner, the shaft is advanced to the 1,500 and 2,000 indicated levels when the storage in the relay units builds up to the required point.

For controlling movement of the cam shaft in the "down" direction, the 371_b switches of all the units and the $J1_5$ switch are arranged to close a circuit for the down magnet DM. Similar circuits for the other levels are provided by the switches 372_b, 373_b and 374_b and the switches $J1_{10}$, $J1_{15}$ and $J1_{20}$, respectively. As explained before, the *b* switches of the relay units are opened when the storage level of the unit passes a predetermined point and closed when the storage level falls below that point. Thus assuming that the cam shaft is set in the second rest position or 500 indicated level, switch $J1_5$ will be closed. Accordingly, if the storage of any relay unit falls below the 500 level, closure of its switch 371_b will complete a circuit for the "down" magnet DM, thus causing the cam shaft **401** to be moved back to its normal rest position or zero indicated level. Similarly, a "down" movement of the cam shaft is initiated from any indicated level when the storage level of any relay unit falls below the indicated level in which the cam shaft is positioned. Thus the cam shaft is moved in either direction in accordance with the rise and fall of the storage levels of the relay units to enable it to perform its intended function of distributing traffic uniformly over the several units. This is done through the medium of the K switches which with the *a* switches of the several relay units mark the units available at the solicitor by closing their respective plunger magnet circuits in preferential order.

The solicitor.—As indicated above, the solicitor PS is a device which effects actual selection of the particular one of a group of available relay units and assigns that unit for the reception of the next message to be transferred. The selection is accomplished positively by advance of the plunger **369** (Fig. 19) individual to the selected relay unit as will be described in detail presently. The solicitor is adapted to perform the selecting operation substantially instantaneously without regard to the position of the unit in its group, there being no delay for testing intervening non-available relay units. As a result, no time is lost in initiating transfer of messages from the primary relay units to the intermediate relay units, thus enabling the exchange equipment to handle a maximum volume of traffic and at the same time materially speeding up delivery of messages to the exchange subscribers. For convenient reference the solicitors are identified by suffixes 1, 2 and 3 indicating the first, second and third groups of intermediate relay units respectively. Inasmuch as all are of similar construction and operate in exactly the same manner, a description of one will suffice.

In the preferred form shown in Figs. 19, 19^a and 19^b, the plungers **369** are arranged around the periphery of a circular frame **441**. Each plunger comprises an elongated bar, preferably of generally rectangular cross-section, beveled on its inner end to present on one side only an inclined surface **442** (Fig. 19^a). The plungers are supported in a horizontal position and each is guided for endwise movement in a slot formed in a stationary member **443** encircling the frame **441**, the slots radiating from the axis of the frame.

Suitable means is provided for yieldably urging the plungers inwardly or toward the frame **441**. As herein shown, this means comprises leaf springs **444** bearing against a cross bar **445** individual to each of the plungers and operatively connected therewith by a yoke **446**.

The plungers are normally held in a retracted position by two separate restraining means. One of these restraining means comprises a bail **447** in the form of a pivoted lever rigid with the armature of the associated plunger magnet PM. The bail as herein shown is of generally U-shaped form and its free end is adapted to hook over an upstanding lug **448** adjacent the inner end of the plunger. A spring **449** tends to draw the bail into engagement with the lug to hold the plunger in its outer or retracted position, the bail being withdrawn to release the plunger upon energization of the associated plunger magnet. As explained above, the plunger magnets are energized only when the corresponding relay units are marked available for the reception of messages by the action of the level switching mechanism. Accordingly, the plungers are released only when their relay units are in condition to receive messages.

The plungers released in the above manner are held against movement until a predetermined point in the operating cycle of the solicitor by the other restraining means referred to. This means comprises a series of bell crank levers **451**, one for each plunger. The bell cranks are pivoted on a stationary part of the framework with one arm projecting upwardly into the path of a lug **452** depending from the underside of the associated plunger. The other arm of each bell crank terminates in a tip engaging in a grooved collar **453** integral with a sleeve **454** slidable on a hollow shaft **455** which in turn is slidably mounted on a vertical rock shaft **456** extending through and coaxial with the frame **441**.

It will be apparent that movements of the collar **453**, between an upper and a lower position, will be effective to rock the bell cranks **451** into or out of blocking relation to their associated plungers and, additionally, to return advanced plungers to their retracted positions. The collar is normally held in its upper or blocking position and is moved to its lower or releasing position for a portion of each operating cycle through the medium of a cam shaft **460** hereinafter called the solicitor cam shaft. Positive

movements are imparted to the collar by suitable cams 461 acting on a double follower 462 fast on a horizontal rock shaft 463. Also fast on this rock shaft are a pair of spaced crank arms 464 straddling the sleeve 454 and each having pivoted on its inner face a drive block 465 confined between upper and lower disks 466 rigid with the sleeve.

The cams 461 are timed so that the bell cranks are withdrawn to release the plungers at the proper point in the operating cycle and then returned to restore all plungers after the selection of the relay unit to receive the next call. In this way the plungers of all available relay units associated with this solicitor are released simultaneously.

The released plungers all move forwardly under the influence of their respective advancing springs but only one of these plungers is permitted to execute its full stroke whereby its associated relay unit is assigned for the reception of the next message to be transferred. The selection of the plunger to move through a full stroke is effected mechanically and in a positive manner which effectually prevents simultaneous advance of two or more plungers.

The selecting means, as herein shown, comprises a series of circulating blocks 471 slidably supported in an endless circular guideway formed by vertically spaced plates 472 and 473 constituting a part of the frame 441. The guideway is formed in this instance by an annular groove 474 in the lower face of the plate 472 and an upwardly facing shoulder 475 formed by a recess in the periphery of the lower plate 473. A guard 476 encircling the plate 473 holds the blocks in position on the shoulder.

The blocks 471 are formed on the same radius as the groove 474 so as to slide easily therein and each is formed at one edge with a notch having an inclined surface 477 engageable by the inclined inner end of one of the plungers 369 whereby the block is moved downwardly or in a clockwise direction as viewed in Fig. 19a. In order that the block may move sufficiently to accommodate an advancing plunger, a gap or space equal to the width of a plunger is left in the series of blocks. Accordingly, only one plunger at a time can advance in its full stroke and in so doing the block which it engages as well as intervening blocks are shifted in a clockwise direction to fill the vacant space.

In case two or more plungers are released simultaneously as may happen on occasion when several of the relay units are available for the reception of messages, the first plunger clockwise of the space left by the previously advanced plunger is given preference. This is for the reason that in their initial advance the straight tips of the plungers are entered in back of the next adjacent block (on the side opposite the inclined surface 477) so as to effectually hold that block and preceding ones against movement. It will be seen, therefore, that the space left by any plunger in one operating cycle constitutes the reference point for selecting the plunger to be entered in the next operating cycle. This reference point changes constantly as the blocks circulate around the guideway, thus tending to give the plungers preference in the order in which their associated relay units become available.

The selected plunger in its forward movement operates to set up a transmission circuit from the primary relay unit in which the message is stored to the selected intermediate relay unit and additionally to mark the latter unit busy or unavailable for other messages. As herein shown, the transmission circuit is established by the closure of a normally open switch 481 (Figs. 19 and 22) through engagement of the movable switch member by the cross bar 445. Closure of switch 481 completes a circuit from ground, common conductor 482, winding of a relay 483 whose function will be explained later, conductor 484, switch 481, pilot line 485 to conductor 229 of the local trunk line individual to the selected relay unit. As previously explained, ground potential on the pilot line energizes the associated selector magnet SM of the primary relay unit which releases a control bar for closing the line switch LS to connect the local trunk line with the transmitting mechanism of the primary relay unit. The connection thus established is maintained independently of the solicitor until terminated by control mechanism embodied in the primary unit as previously described.

The selected intermediate relay unit is marked busy by the opening of a normally closed switch 486 actuated in this instance by the cross bar 445 in the advance of the plunger. Opening of this switch interrupts the circuit for the availability magnet 313 and the plunger magnet PM. The latter restores the bail 447 to latching position. The availability magnet when deenergized allows the mechanically operated availability switch 311 to open, thus preventing reenergization of either magnet until the switch is again closed following the receipt of a complete message as before explained.

Means is provided for locking the circulating blocks 471 against displacement when the plungers are withdrawn and for aligning the blocks so that their notches register accurately with the respective plungers. This means, as herein shown, comprises a series of upstanding latch fingers 489 mounted on a circular plate 490 rigid with the upper end of the hollow shaft 455 and operable when moved vertically to engage in complementary notches 491 in the lower edges of the blocks. The front wall of each notch is beveled as indicated at 492 and the latch fingers are so located that the blocks are cammed back slightly each time the fingers are entered to insure sufficient clearance for the entry of the plungers.

Entry and withdrawal of the latch fingers are effected positively and in timed relation to the withdrawal of the plungers through the medium of suitable cams 493 carried by the solicitor cam shaft 460. As herein shown, the cams coact with a double follower 494 carried by a rock shaft 495. Movements of the rock shaft are imparted to the hollow shaft 455 and latch finger assembly by rigid crank arms 496 spaced apart to straddle a sleeve 497 fast on the hollow shaft. Drive blocks 498 pivoted to the respective crank arms and confined between upper and lower plates 499 rigid with the sleeve 497 provide an operative connection between the parts.

The operating cycle of the solicitor is controlled by the cam shaft 460 which, in this instance, is driven by a positively acting clutch 500 preferably of the bar type similar to the clutch 71 hereinbefore described. The driven member of the clutch is fast on the cam shaft and the driving member is rotated continuously from any suitable source of power, but in timed relation to the drives of the relay units. Engagement and disengagement of the clutch is controlled by a finger 501, which acts through

a rack and pinion connection indicated generally at 502 to shift a bolt 503 into or out of notches 504 in the periphery of a disk-like member 505 forming a part of the driving member.

Cooperating with the clutch finger 501 is a detent 506 comprising in this instance, an extension of the armature of a magnet 507 hereinafter called the solicitor stop magnet. A spring 508 normally holds the detent out of the path of the clutch finger whereby the latter, through the action of a spring 509, is rotated sufficiently to enter the bolt 503 and thus engage the clutch in well-known manner. The stop magnet, when energized, moves the detent into the path of the clutch finger, thereby withdrawing the bolt and disengaging the clutch.

The stop magnet 507 is energized to stop the cam shaft and thus prevent withdrawal of an advanced plunger until the selected relay unit, represented by the plunger, is seized by the primary relay unit which holds the message to be transferred. As herein shown, the energizing circuit for the magnet is completed by a switch 510 (Figs. 19 and 22) closed as an incident to the advance of the plunger. When the relay unit is seized, relay 483 energizes in series with the selector magnet SM of the primary unit and opens a switch 511 to interrupt the circuit for the stop magnet and thus restart the cam shaft for selection of the intermediate unit to receive the next message.

Closure of the switch 510 is also utilized to start the time assigner PT_1 associated with the solicitor PS_1. To this end the switch is connected with a pilot wire 512 which is multipled through all of the primary relay units of the exchange as shown in Figs. 21, 24 and 27. When any primary unit such as the unit PR_1 (Fig. 21) has a message directed to the group of intermediate relay units served by the solicitor PS_1 the pilot wire is extended by way of a branch conductor 513 (Fig. 21), switch R11 and a conductor 514 to a time assigner plunger magnet TPM individual to the primary relay unit.

Since switch 510 must be closed when any intermediate relay unit of the group is seized, means is provided to enable any plunger of the solicitor to actuate the switch. This means in its preferred form comprises a switch actuating member herein shown as an arm 515 (Fig. 19) fast on the lower end of the rock shaft 456. A spring 516 normally holds the actuating member against a stop 517 thus allowing the switch contacts to open.

Fast on the upper end of the shaft 456 is a star wheel 518 having a series of notches (one for each plunger 369) each formed with an inclined surface engageable by the beveled tip of a finger or extension 519 integral with the associated plunger. The notches are so positioned that a plunger on advancing through its full stroke exerts a camming action on the inclined surface of the corresponding notch to rock the star wheel and shaft in a direction to close the switch 510.

The switch actuating mechanism above described also acts to open a normally closed switch 520 upon the advance of any one of the plungers. This switch, jointly with a switch 521 closed by a cam 522 on the solicitor cam shaft, controls the level shunt mechanism which will be described next.

Level shunt mechanism

It will be recalled that in the normal operation of the primary distributing mechanism, no messages are routed to an intermediate unit above the indicated storage level. However, when all relay units below the indicated storage level are busy, the selecting action of the level switcher is temporarily suspended so that a connection may be sought with a non-busy relay unit with storage above the indicated level (but below the 2,000 level). This is accomplished by closure of switches 526, 527 and 528 (Figs. 19 and 22) conveniently called level shunt switches which complete shunt circuits around the 2,000 level switches $1K_{20}$, $2K_{20}$ and $3K_{20}$. These K switches of the relay units below the 2,000 level are open, of course, but closure of the shunt switches energizes the plunger magnets of all such units that are not busy so that one of the units may be assigned to receive the waiting message.

While any suitable means may be employed for actuating the shunt switches, it is preferred to employ a cyclically operable shaft 529 having a cam 530 operable through a cam follower 531, rock shaft 532, rigid arm 533 and push rod 534 to shift the movable contact members of the switches between open and closed positions. The cam is shaped so that the switches are open when the shaft is in its normal rest position and closed when the shaft is in an intermediate position.

For driving the shaft 529 there is provided a clutch 535 similar in all respects to the clutch 500. The clutch 535 has the usual control finger 536 cooperating in this instance with two detents 537 and 538. The first detent is positioned to block the clutch finger and stop the shaft in the normal rest position while the latter detent is positioned to block the finger and stop the shaft in the intermediate position. In the particular embodiment illustrated, the detents are adapted to be actuated by magnets 539 and 540, respectively. Detent 537 is normally held in blocking relation to the clutch finger by a spring 541 and is withdrawn to engage the clutch upon energization of the magnet 539. Detent 538, on the other hand, is normally held out of the path of the clutch finger by a spring 542 and is moved into clutch disengaging position upon energization of the magnet 540.

To enable the level shunt mechanism to function at the proper times, the detent actuating magnets 539 and 540 are connected in parallel in a control circuit which includes the normally closed star wheel switch 520 and the normally open cam switch 521 in series. The cam 522 is timed so as to close the switch 521 only after an interval sufficient to allow a plunger to advance. Thus, if a plunger advances, switch 520 opens the magnet circuit so that the level shunt mechanism remains inactive.

In case all intermediate relay units of the group are unavailable, no plunger is advanced in that part of the solicitor cycle in which a plunger should advance and the star wheel switch 520, therefore, remains closed, while the switch 521 is closed by the cam. Magnets 539 and 540 are accordingly energized to withdraw the detent 537 and enter the detent 538, respectively. Withdrawal of the detent 537 engages the clutch 535 which drives the level shunt cam shaft through its first step. Detent 538 disengages the clutch to stop the cam shaft in the intermediate position. In this position the level switches 526, 527 and 528 are closed and if any of the relay units above the indicated storage level but below the 2,000 level are non-busy, their plunger magnets are energized and one of those units is selected in the next operating cycle of the solicitor. In case

all relay units are above the 2,000 storage level, the switch 521 opens at the end of the solicitor cycle and detent 538 is withdrawn. The cycle is, therefore, repeated until a receptive relay unit is found, that is, until one of the relay units transmits stored message matter to bring the storage level below the 2,000 level and, when that relay unit becomes idle, it is seized for the transfer of the next message destined for that group. The advance of a plunger to seize the relay unit opens the switch 520 thus deenergizing magnet 540 which withdraws the detent 538 and thereby reengages the clutch 535 to drive the cam shaft back to its normal rest position.

Time assigner

The function of the time assigners PT will be apparent from the foregoing description of the operation of the distributing mechanism. Briefly stated, each time assigner acts to condition the primary relay units of its group one at a time for seizing the intermediate relay units assigned by the solicitor. To avoid the delays that would result from testing the primary units in succession for waiting messages, it is preferred to utilize a selecting device operating on the same principles as the solicitor, that is, one capable of selecting the waiting primary units without regard to their relative positions in the group.

Referring now to the time assigner illustrated in Fig. 20, the plungers 370 and their associated plunger magnets TPM, of which there is one for each primary relay unit served by the time assigner, are arranged in a circle about a frame 541a carried on a vertical shaft 542a. The plungers 370 are similar to plungers 369 previously described, except for the omission of the star wheel actuating fingers and like those plungers are supported for endwise movement radially toward and from the frame 541a.

Selection of a plunger to advance to its full stroke is effected by a series of circulating blocks 543 exactly like the blocks 471 and arranged in the same manner in a circular guideway in the frame 541a. Each of the plungers is urged inwardly by leaf springs 544 bearing on a cross bar 545 operatively connected with its plunger by a yoke 546. A bail 547 actuated by the associated plunger magnet TPM holds the plunger retracted until the corresponding primary relay unit is ready to relay a message. When the first message link is advanced to the transmitting control point, the selector mechanism of the primary relay unit prepares a circuit for the plunger magnet by closing an appropriate selector switch, for example, the switch R11 in the case of a first class message. This circuit is completed when the solicitor grounds the pilot line 512 as before explained, thereby energizing the plunger magnet to release the associated plunger.

The plungers so released are permitted to advance at a predetermined point in the operating cycle by withdrawal of individual restraining bails each comprising a pivoted bell crank 548 having one leg engageable with a depending lug on one of the plungers. The other legs of the bell cranks engage in a grooved collar 549 slidable vertically on a hollow shaft 550 enclosing the shaft 542a. The collar is raised and lowered in each cycle by a cam 551 acting through a follower 552. As the time assigner and associated solicitor are required to operate in synchronism the cam 551 may be conveniently mounted on a shaft 553 driven in synchronism with the solicitor cam shaft 460 through the medium of a gear 553a. A second cam 554 on the cam shaft acts through a follower 555 to impart movements to the hollow shaft 550 so as to enter locking fingers 556 when the plungers are retracted and to withdraw the locking fingers when the plungers are released.

A selected plunger on moving through its full stroke acts through the associated cross bar 545 to close a switch 557. Closure of the switch applies ground to a conductor 558 (Figs. 21, 24 and 27) multipled through all of the time assigners and connected to the testing magnet 253' of the calling primary relay unit. As explained before, the test magnet when energized releases the J-cam shaft of the unit for movement from the No. 2 to the No. 3 rest position. In other words, closure of the plunger magnet switch indicates connection of the primary relay unit to the intermediate relay unit assigned for the reception of the message.

The primary distributing mechanism for the first group of intermediate relay units described above is duplicated for each of the other groups of units and corresponding parts are identified in the drawings by the same reference characters. The operation of each mechanism is confined, of course, to handling calls directed to its own group of intermediate units. Thus, in the case of ordinary messages, the selecting relay R2 of the calling primary relay unit is energized under control of the class of message signal to close a circuit by way of a conductor 561 for the corresponding plunger magnet of the time assigner PT_2 shown in Fig. 24. The associated solicitor PS_2 and level switching mechanism shown in Fig 25 operate to select one of the available intermediate relay units of the second group and the solicitor applies ground to a pilot wire 562, a branch 563 of which extends to selector switch R21. Upon advance of the plunger associated with the energized plunger magnet, the switch 557 is closed to complete an energizing circuit for the test magnet 253' of the primary relay unit exactly as occurred in the operation of the first class message distributing mechanism. Solicitor PS_2 completes an energizing circuit for one of the selector magnets SM_4—SM_6 by applying ground to the pilot line 564 individual to the selected intermediate relay unit.

The same sequence of operations occurs in the case of third class or delayed messages. In this instance the selector relay R3 of the calling primary unit energizes and prepares a circuit for one of the plunger magnets of the time assigner PT_3. The solicitor PS_3 and level switching mechanism shown in Fig. 28 assign an available one of the intermediate relay units from the third group. The solicitor applies ground to a pilot line 565 connected by a branch line 566 with the selector switch R31 of the calling primary unit. Solicitor PS_3, like the solicitors previously described, energizes one of the selector magnets SM_7—SM_9 of the calling primary relay unit by applying ground potential to one of the pilot wires 567 as before explained.

Secondary distributing mechanism

Time assigners.—The flow of traffic from the intermediate relay units to the terminal relay units is controlled by the secondary distributing mechanism which is preferably mechanically similar to the primary distributing mechanism above described. As the messages stored in the intermediate units are relayed either to terminal units individual to subscribers' lines, or to relatively small groups of interoffice trunk lines, no

level switching mechanism is required. Solicitors are required only where a plurality of terminal units are designted by the same address signal as where a plurality of lines or trunks lead to the same destination. One such trunk group is shown in Fig. 26, comprising the two trunk lines Ta leading to the exchange B. The two terminal relay units TR_3, TR_4 associated with these trunk lines are assigned selectively for the reception of messages by the secondary solicitor SS.

The time assigners in this case are individual to the three groups of intermediate relay units and are designated respectively by the reference characters ST_1, ST_2 and ST_3. In order to provide for the transfer of messages of different classes in the desired order of preference, the time assigners are interlocked so that first class messages are given the right of way over all other messages. Ordinary messages are forwarded only when no first class messages are awaiting transfer. Third class or delayed messages are held until there are no messages of other classes awaiting transfer. The interlocking of the time assigners is effected in this instance through the medium of interlocking circuits which are also arranged to prevent interference with any time assigner once its operation has been initiated.

The time assigners ST, ST_2 and ST_3 are shown diagrammatically in Figs. 23, 26 and 29. Structurally these time assigners are identical with the time assigner PT_1 previously described in detail, each having a plunger and asscciated plunger magnet PM_t for each intermediate relay unit of the group served by the time assigner. In this instance, however, each of the time assigners is equipped with star wheel switch operating mechanism exactly like that of the solicitor PS_1. These mechanisms control switches in the interlocking circuits for the time assigners as will appear presently. As in the previously described time assigners and solicitors, the plunger magnets actuate one restraining means for holding the plungers retracted while the other restraining means is actuated cyclically by the time assignor cam shaft which in this instance may be continuously driven.

As shown in Figs. 23, 26 and 29, the plunger magnets PM_t, of the time assigners, are connected respectively to bus conductors **571**, **572** and **573**, to each of which ground is applied by way of an interlocking circuit controlled by the other two time assigners. Thus, in the case of the first time assigner ST_1 the interlocking circuit may be traced from the bus conductor **571**, winding of a relay R5 (Fig. 23), conductor **574**, star wheel switch **575** (Fig. 26) of the second time assigner, conductor **576**, the star wheel switch **577** (Fig. 29) of the third time assigner to ground. With this arrangement, operation of the first time assigner is prevented if either of the other two time assigners is in operation, that is, if a plunger has advanced to open the star wheel switch of the time assigner.

Referring now to Fig. 26, the interlocking circuit for the second time assigner extends from the bus conductor **572**, winding of a relay R6, conductor **578**, star wheel switch **579** (Fig. 23) of the first time assigner, normally closed switch R5*1* of relay R5 and thence through the previously traced interlocking circuit to ground by way of conductor **574**. Thus, the second time assignor cannot operate when either the first or third time assignor is in operation. Moreover, the second time assignor cannot operate as long as the first time assigner has a relay unit waiting to transfer a message, because in that case the relay R5 will be energized in series with the plunger magnet PM_t of the waiting relay unit. In this way relay units of the second group are forced to wait until all of the first class intermediate units having messages ready for transmission are connected through to terminal units.

In the case of the third time assigner, the interlocking circuit may be traced from the bus conductor **573** (Fig. 29), conductor **580**, star wheel switch **581** (Fig. 26) of the second time assigner, conductor **582**, normally closed switch R6*1* of the relay R6, conductor **578** and the previously traced circuit for the second time assigner to ground. Accordingly, time assigner ST_3 is prevented from operating when either of the other two time assigners is in operation. This is for the reason that one or the other of the star wheel switches **579** or **581** will be open under these conditions. Moreover, the third time assigner is prevented from operating when either of the other two time assigners has a relay unit waiting with a message to be transmitted since in that case one or both of the relays R5 and R6 will be energized and their associated switches R5*1* and R6*1* will be open. It will be apparent, therefore, that through the operation of the time assigner interlocking circuits intermediate relay units are selected for transmission in the order of preference of the messages stored therein without, however, allowing any time assigner to interfere with another already in operation.

Before describing the switching operations involved in the establishment of a connection between a selected intermediate unit and a terminal unit, it will be advantageous to consider the construction and mode of operation of the secondary solicitor SS.

Secondary solicitor.—The secondary solicitor SS shown diagrammatically in Fig. 26 is structurally similar to the primary solicitor PS_1 previously described. In the particular environment illustrated, this solicitor is arranged to select between the two terminal relay units TR_3 and TR_4 for the trunk lines Ta extending to the exchange B. The solicitor has a plunger magnet PM_s for each terminal relay unit, the magnets controlling restraining means for the plungers which also have cyclically operable restraining means as before described.

When the terminal unit TR_4 is available for the reception of a message, its associated plunger magnet is energized over a circuit from ground, availability switch **591**, conductor **592**, winding of the plunger magnet, plunger switch **593**, bus conductor **594**, and conductor **595** to negative battery. When the terminal unit TR_3 is available, its plunger magnet is energized over a circuit from ground, availability switch **596**, conductor **597**, winding of the plunger magnet, plunger switch **598**, bus conductor **594**, and conductor **595** to negative battery. One of the plungers released by the energization of the plunger magnets will advance through a full stroke in the manner previously described, and in so doing will open its switch **593** or **598** and close its associated pilot switch **602** or **608a**, at the same time closing a star wheel switch **599**.

Assuming by way of illustration that the terminal unit TR_4 has been selected to receive the next message by advance of the corresponding plunger of the solicitor, a circuit is completed from negative battery, winding of a magnet **600** hereinafter called the solicitor control magnet,

bus conductor 601, pilot switch 602, conductor 603 of the secondary trunk line STL, which conductor is connected to the bus circuit conductor 340b through the supervisory switchboard SB (Fig. 31).

Assume by way of illustration that the intermediate relay unit IR_1 of the first relay group has a message awaiting transfer to the selected terminal unit. A starting circuit for the time assigner ST_1 is established from battery, star wheel switch 599 (Fig. 26) of the solicitor SS, conductor 605 which as a matter of convenience is incorporated in the secondary trunk line STL_3 for the terminal unit TR_3 and which is connected to the bus conductor 336a, switch 335a, closed by its partially advanced selector bar as previously explained, switch 337, conductor 338 to the plunger magnet PM_t to ground through the interlocking circuit of the time assigner ST_1. The plunger magnet releases its plunger in the usual way and the plunger, on advancing, initiates the movement of the J-cam shaft of the relay unit IR_1 from the No. 2 to the No. 3 rest position.

The line switches 339a, 335a and 339b are closed as previously explained due to the partial advance of the selector bars. Negative battery potential on the bus conductor 340b will, therefore, be extended by way of the latter switch, winding of selector magnet SM_{10} to energize the same. The magnet acts through its code bar 317 to release the selector bar for seizing the trunk line STL_4 and thus establish a transmitting path from the intermediate relay unit IR_1 to the terminal relay unit TR_4.

Referring again to Fig. 26, closure of the star wheel switch 599 also completes a circuit for a magnet 607 hereinafter called the solicitor stop magnet which on energizing disengages the solicitor cam shaft clutch in the same manner as the stop magnet 597 of the primary solicitor. The solicitor is thus maintained in idle condition until the selected terminal unit is seized by an intermediate relay unit whereupon the control magnet 600 is energized in series with the selector magnet of the intermediate relay unit as above described. Magnet 600 on energizing opens a switch 608 to interrupt the circuit of the stop magnet 607 which deenergizes and thus restarts the solicitor cam shaft for the next operating cycle.

The same sequence of operations are involved when the terminal unit TR is selected to receive the next message. The time assigner is started by closure of the star wheel switch 599 or the switch 337, depending on which closes first. In this case, however, the plunger magnet extends the circuit for the magnet 600 by way of a pilot switch 608a to secondary trunk conductor 609 which is connected to the bus conductor 340a. When the J-cam shaft is now released from the No. 2 rest position by the time assigner, a circuit is extended by way of closed line switch 339a to one terminal of the selector magnet SM_{11} which on energizing releases the selector bar for seizing the secondary trunk line STL_3 leading to the terminal unit TR_3. After a transmission path is established in the above manner, it is tested and the message stored in the intermediate relay unit is transferred to the terminal unit by simultaneous transmission and is received and recorded at the terminal unit by mechanism to be described presently.

In the case of messages destined for individual trunk lines or subscribers' lines, the secondary solicitor SS is inactive but the time assigners function in the usual way to assign testing time to their respective relay units in the predetermined order of preference. Thus when the relay unit IR_1 (Fig. 22) has a message for a subscriber of the exchange C, the selector bar for the line switch ILS_5 is operated in its first step to close the switches 335 and 339. A circuit is thus prepared for the plunger magnet at the time assigner ST_1 individual to that relay unit by way of the switch 335, conductor 611 of the bus circuit IB_5, conductor 612 of the secondary trunk line STL_5, availability switch 613 of the terminal relay unit TR_5 to battery.

The availability switch of the relay unit is closed mechanically at the end of each message in the same manner as the switch 311, previously described, and it is held closed by an availability magnet 614. The magnet is energized in the local circuit including the availability switch and a normally closed switch 615 of a relay 616. When the terminal unit is seized for the transfer of a message, the relay is energized in series with the selector magnet SM_{11} of the calling intermediate relay unit over a circuit including conductor 617 of the trunk line, but circuit conductor 618, and switch 339 of the operated line switch.

Relay 616 upon energizing opens the circuit of the availability magnet which becomes deenergized and opens the availability switch 613 thus marking the terminal unit unavailable for other calls. The time assigner previously closed its pilot switch for grounding the pilot wire 338a to energize the test magnet 253' of the intermediate relay unit and thereby release the J-cam shaft for movement from the No. 2 to the No. 3 rest position. In this movement the selector bar is released for its second operative step thus completing the transmission path to the terminal unit TR_5.

Terminal units TR_1 and TR_2 (Fig. 29) associated respectively with the subscribers' receiving lines RL_p and RL_q are seized in the same manner as the unit above described. Each of these units has an availability switch 619 held in closed position by an availability magnet 620. The switch for unit TR_1 is connected to a conductor 621 of the secondary trunk line STL_1 while the switch for unit TR_2 is connected to conductor 622 of trunk line STL_2. These trunk conductors are extended by way of their respective bus circuit conductors and the switches 335 of line switches ILS_1 and ILS_2, respectively to the plunger magnet of the time assigner when a message is presented for the corresponding subscriber's station. The availability magnets are controlled switches 623 each operated by a relay 624 energized in series with the selector magnet SM_{11} of the calling intermediate relay unit. The circuit for the relay of the unit TR_1 includes a conductor 625 of trunk line STL_1, a bus circuit conductor and switch 339 of line switch ILS_1. The relay for the unit TR_2 is energized over a circuit including conductor 626 of trunk line STL_2 and switch 337 of line switch ILS_2.

Following the seizure of any relay unit, the usual test signals and the message signals are transmitted to the recorder of the terminal unit which will now be described.

Terminal relay units

General.—The terminal relay units, like the units previously described, are each composed of a recorder, a signal storage mechanism and a transmitter. In the particular system illustrated, the recorder is exactly like the recorders for the

intermediate relay units except for the slight change in the availability circuit above described and the omission of the level switching mechanism.

As shown in Figs. 23, 26 and 29, each recorder is provided with five line magnets **156'** connected respectively to the five impulse conductors of the associated secondary trunk line. They are also the usual O. K. switches **306** and **307** closed by the test signal feelers when the test signals have been properly received and recorded. These switches energize the trouble magnet **352** of the calling intermediate relay unit as before explained to permit transmission of the message signals. The full storage stop switch **540'**, like the correspondingly numbered switch of the intermediate relay units, is opened when the supply of blank links is exhausted and its acts to stop the chain advance at the calling relay unit and thereby interrupt signal transmission.

Incoming signals are recorded on the storage medium or pin chain of the storage mechanism which is exactly like that of previously described relay units and, therefore, requires no further explanation. The recorded signals actuate the transmitter which may be arranged to retransmit them according to any desired system of transmission. By way of illustration, one terminal relay unit, namely the unit TR_5 (Fig. 23) associated with the trunk line outgoing to exchange C, has been shown with a transmitter arranged for simultaneous transmission while the remainder of the terminal units are equipped with transmitters arranged for start-stop transmission.

Simultaneous transmitter.—Referring to Fig. 23, the transmitter for the terminal relay unit TR_5 is substantially identical with the transmitters of the intermediate relay units except for the omission of certain features which are not essential to the performance of the functions of this unit. Thus, since the terminal unit is individual to a trunk line, no selective operation is required. The line selector mechanism is, therefore, omitted and the impulse conductors of the trunk line are extended directly to transmitting switches TS of the relay unit transmitter. The commutation switch CS and cam switch **344** are connected in series with the transmitting switches as previously explained. The trunk line also has a control conductor connected to the full storage stop magnet **545'** so that transmission may be interrupted in case of full storage condition at the receiving relay unit at the distant exchange.

Start-stop transmitter.—The start-stop transmitter is, in many respects, similar to the transmitter above described. Thus, it has the usual set of five transfingers corresponding to the transfingers STF shown in Figs. 10 and 11a which control transmitting switches TTS shown in Figs. 26 and 29. These transfingers have their pin engaging shoes positioned in operative relation to the transmitter loop **7'** of the storage chain at the transmitting control point, the arrangement being such that non-pushed pins engage their corresponding shoes and open the associated switches TTS. The pushed pins clear the transfinger shoes, hence the associated switches are closed. In this way the switches are set in combinations corresponding to the signal recorded on the link at the transmitting control point.

The storage chain is fed by the usual sprocket wheel **58'** (Fig. 33) driven by a positive clutch indicated generally at **260'**. The clutch is preferably of the quick-acting spur gear differential type shown in the prior application which is especially suited for the intermittent operation required in start-stop transmission. As explained in detail in the said application, the clutch is engaged and disengaged by actuation of its detent **271'** under control of a detent setter **272'**. The detent setter is continuously driven by an eccentric on a shaft **274'** geared to the main transmitter drive shaft. In the present instance the shaft **274'** is driven at a rate of 3,600 revolutions per minute so that the clutch detent may be entered or withdrawn in any link cycle of the relay unit. When the detent is entered, the sprocket wheel **58'** is rotated at a rate such as to advance the chain one link step for each signal cycle of the receiving telegraph printer.

Power actuated means is provided for moving the detent setter **272'** to its lower or detent entering position, the detent setter being normally urged into its upper or detent withdrawing position by the cam means shown and described in the prior application. The power actuated means as herein shown comprises a floating lever **FL9** loosely mounted on a rod **282'** carried by a pair of arms **283'** fast on a shaft **284'**. This shaft is oscillated by a double acting cam device **285'** on the shaft **274'**.

One end of the floating lever **FL9** is connected by a link **286'** with a crank arm **287'** fast on a rock shaft **277'** which has a second crank arm **278'** connected by a link **279'** with the outer end of the detent setter. Thus when the free end of the floating lever is blocked against movement on its active stroke it becomes fulcrummed at its free end and the opposite end is positively actuated to rock the shaft **277'** in a clockwise direction (as viewed in Fig. 3) and thereby shift the detent setter to its lower position. When the free end of the floating lever is not blocked it fulcrums about the connection with the link **286'** and the detent setter remains in its upper or clutch disengaging position to which it has been returned by the cam mechanism previously mentioned.

For the purpose of blocking the floating lever **FL9** in its control of the detent setter, a latch **L9** is provided (Fig. 33). The latch in this instance constitutes the armature of a latch control magnet LCM, the latch being pivoted adjacent one end on the heel-piece of the magnet and having its free end positioned for movement into or out of the path of the free end of the floating lever. A spring **631** normally holds the latch in withdrawn position and the control magnet, when energized, moves it into blocking relation to the floating lever.

Two separate control circuits are provided for energizing the latch control magnet in different stages of the message cycle. One of these circuits acts to initiate the advance of the storage chain to the transmitting control point while the other circuit controls step-by-step advance of the chain during the transmission of the message. The first of these circuits is arranged to become effective automatically whenever there is message matter in storage at the terminal unit and the transmitter is idle. The circuit remains effective until the first message link is presented at the transmitting control point whereupon the second control circuit takes charge of the feed mechanism. As shown in Fig. 29, the first control circuit for the latch magnet includes a pair of switches **632** and **633** connected in series with the magnet and the opposite poles of the current source or battery.

Referring now to Fig. 33, the switch 632 is arranged to be actuated by a cam 634 on the J-cam shaft 232' of the transmitter. This shaft is identical with the J-cam shafts of the other units previously described and like them is held in its No. 1 position when the transmitter is idle. The shaft is released for movement to the succeeding rest position in response to the presentation of the first message link to the presence of message feeler CF2 (Fig. 10). Since the terminal relay units are associated individually with trunk lines and subscribers lines, no busy test of the line is required, hence the means for stopping the cam shaft in the No. 2 rest position is omitted. Moreover, the terminal relay units are ordinarily not arranged to transmit test signals so no means is provided for stopping the cam shaft in the No. 3 or double position. Accordingly, the cam shaft when released, moves immediately to the No. 4 rest position or message transmitting position.

As shown in Fig. 33, the cam 634 is adapted to actuate the switch 632 through the medium of a follower 635 and spring biased push rod 636. The cam is formed to effect closure of the switch when the cam shaft is in its No. 1 or idle position, and to open the switch as the cam shaft approaches the end of the first step or what corresponds to the No. 4 rest position of an intermediate relay unit cam shaft.

The switch 633, as herein shown, is adapted to be actuated by the storage indicator mechanism of the transmitter. This mechanism is exactly like that of the basic relay unit shown and described in the prior application. Briefly stated, it comprises a threaded shaft 307' adapted to be rotated in one direction (counter-clockwise as viewed in Fig. 33) by a connection with the recorder and in the other direction by a connection with the transmitter. Loosely mounted on the shaft is an arm 317' adapted to be shifted longitudinally of the shaft and into the path of a pin 313' carried on a crank arm 314' fast on the shaft and rotatable therewith. Shifting of the arm is effected by a traveler (not shown) threaded on the shaft so as to move toward or from the arm 317' according to the direction of rotation of the shaft. The arrangement is such that the arm is shifted into position to be engaged by the pin and rocked to the position shown in Fig. 33 as the last message link is withdrawn from the storage section of the storage mechanism. When message links are fed into the storage mechanism from the recorder, the crank arm 314' is immediately rocked so as to move the pin away from the arm 317' and the latter is drawn to its alternate position against a stop 637 by the spring 638.

The free end of the arm 317' is formed to provide a cam adapted to actuate the switch 633 through the medium of a follower 639 and push rod 640. The arrangement is such that the switch is closed when there is any message matter in storage and open when the last message link is withdrawn from storage. Thus it will be seen that both switch 632 and switch 633 are closed if the transmitter is idle and there is a message awaiting transmission.

Closure of the switches 632 and 633 completes an energizing circuit for the latch magnet LCM which enters the latch L9 to block the floating lever FL9. The latter acts to position the detent setter for engaging the clutch 260' and thus initiates the advance of the chain. When the first message link approaches the control point

it releases the J-cam shaft 232' for movement from the No. 1 rest position as above explained and the cam 634 opens switch 632 to deenergize the latch magnet and interrupt the chain advance. This action is timed so that the chain is stopped with the first message link at the transmitting control point.

The message link at the transmitting control point sets the switches TTS in a combination corresponding to the setting of the pins of the link. This signal combination is relayed over the called line as a series of current and no-current impulses by a distributor which may be of any suitable and well-known type. The distributor shown by way of illustration is substantially like the distributor of the so-called teletypewriter and comprises a start-stop shaft 641 (Fig. 34) driven by a single revolution clutch DC.

The distributor shaft is provided with a series of cams 642, five in the present instance, which actuate associated distributing switches DS_1, DS_2, DS_3, DS_4, and DS_5 in succession. A sixth cam 644 on the shaft is arranged to close a control switch 645 at the end of the signal cycle. This latter switch is interposed in the other control circuit for the latch magnet LCM so that the latter may be energized to initiate chain advance in proper timed relation with respect to the distributor cam shaft cycle.

The clutch DC, which drives the distributor cam shaft, is herein shown as a bar type clutch similar to the clutch 71 previously described. The clutch is normally disengaged by a detent 646 positioned to block the clutch finger 647. A magnet CDM conveniently called the clutch detent magnet is provided for withdrawing the detent to engage the clutch and thus release the cam shaft for a single revolution.

In the exemplary system, the clutch magnet CDM is connected in series relation with the line magnet 5 of the receiving printer at the subscriber's station through the lockout switch 6^a. Thus when the switch 6^a is closed the magnet and the line relay may be energized to start the distributor cam shaft and the receiver cam shaft simultaneously.

The energizing circuit for the clutch magnet and line relay is completed in the present instance by two serially connected switches 651 and 652 (Figs. 29 and 33). The first of these switches is closed by a cam 653 on the J-cam shaft acting through a follower 654 and push rod 655. The cam is so shaped that the switch is closed only when the cam is in the No. 4 rest position so that the distributor and receiving printer can be started only when the transmitter is ready to send.

Switch 652 is arranged to be closed cyclically to complete the distributor starting circuit immediately after the presentation of a message link at the transmitting control point. In order to synchronize the distributor with the other mechanism of the transmitter, the switch is preferably actuated by a cam 656 fast on a shaft 657. As herein shown the cam has a single lobe 658 acting through a follower 659 and push rod 660 to close the switch momentarily. The shaft 657 is positively driven in timed relation to the main drive shaft of the transmitter through a speed-reducing gear train 661. In the exemplary form illustrated, the gear ratios are such that the cam shaft makes one complete revolution in an interval corresponding to a signal cycle of the distributor and receiving printer.

It will be seen from the foregoing that the chain feed mechanism and the distributor are effectively

interlocked to operate in synchronism in the transmission of successive signal combinations. Thus, in response to the presentation of the first signal carrying link at the transmitting control point, the distributor is started in its cycle to send out a series of current and no-current impulses as determined by the setting of the transmitting switches TTS under control of the set pins of the link. Chain feed is interrupted during the distributor cycle by the opening of the distributor cam switch **645**. At the end of the distributor cycle the switch **645** is again closed to energize the latch magnet LCM and thus initiate advance of the chain to present the next link at the transmitting control point. Then the distributor is restarted as above explained and the cycle is repeated for each successive link until the entire message has been transmitted. When the end of message is presented to the feeler CF2, the J-cam shaft is released for movement to its No. 1 or idle position and switch **651** is thereby opened to prevent further operation of the transmitter and distributor until another message is ready for transmission.

Supervisory equipment

Signal apparatus.—Reference has been made heretofore to the supervisory switchboard SB and certain signal instrumentalities incorporated in it have been briefly described. These include the signal lamps **260** (Fig. 30) one of which is provided for each primary relay unit in the exchange. The lamps are lighted when a full storage condition occurs in the corresponding relay unit. In the case of the primary units PR_2 to PR_6, the full storage stop switch **258** applies battery potential to the signal conductor **259** which is connected to one terminal of the associated lamp **260**, the other lamp terminal being connected to ground. The primary relay unit PR_1 is arranged for the reception of simultaneous signals and it is, therefore, most convenient to connect up the full storage stop switch **541'** for applying ground to the signal conductor **259a**. The other terminal of the lamp **260a** is accordingly connected to negative battery.

Signal lamps **250** are also individual to the respective primary relay units and are lighted when the associated units are stopped in the trouble position. For this purpose each lamp is connected by a conductor **249** with the trouble switch **248** of the corresponding relay unit.

Similar full storage signal lamps **308** and trouble signal lamps **348** are provided for each intermediate relay unit of the exchange. In the case of the terminal relay units only full storage signal lamps **665** (Fig. 31) are provided. These lamps are connected by conductors **666** with the secondary trunk line conductors which are grounded by closure of the full storage stop switches **540'** of the respective terminal relay units.

In additional to the signal instrumentalities above described, means is provided at the supervisory switchboard for displaying a signal showing the terminal unit to which each message is directed as it is presented at the transmitting control point of an intermediate relay unit and for indicating the length of time the message is held before transmission. For this purpose there is installed at the switchboard a plurality of groups of lamps **667** (Fig. 30) one for each intermediate relay unit in the exchange. Each lamp group includes a separate lamp for every secondary trunk line accessible to the associated relay unit. Thus, in the exemplary system, five lamps **667** are shown corresponding to the secondary trunk lines STL_1 to STL_5. One terminal of each lamp is connected by a conductor **668** to a switch **669** of one of the line switches ILS (Figs. 22, 25 and 28) of the corresponding relay unit.

Referring more particularly to Fig. 22, the switches **669** are arranged to be closed selectively in the first step of the selector bar upon its release for trunk selection. The switch when closed extends the circuit of the signal lamp to a switch **670** closed by the cam **337a** (Fig. 16a) on the J-cam shaft while the shaft is in the No. 2 rest position. In other words, the lamp circuit is closed while the relay unit is waiting for the selected trunk line to become available. The circuit completed at the switch **670** extends by way of conductor **672** to one side of an alternating current generator ACG (Fig. 30).

The signal lamps **667** of each group are connected in parallel to one terminal of an electrical timing device **673** (Fig. 30), the other terminal of which is connected to the other side of the generator ACG. The timing device may be of any suitable and well-known type such as a synchronous clock mechanism and is preferably arranged for automatic reset upon interruption of its operating circuit.

With the above arrangement, operation of a line switch ILS to select a trunk line, lights the corresponding lamp **667** and starts the associated timing device. The lamp remains lighted and the timing device continues in operation until the relay unit seizes the selected trunk. Seizure is effected as before explained by a movement of the J-cam shaft out of its No. 2 rest position. When this occurs the lamp and timer circuit is interrupted by opening the switch **670**, thus extinguishing the lamp and stopping and resetting the timer. By noting the timers, the attendant can determine when a message has been delayed for an extended period and the particular unit in which the message is stored, as well as the destination for which it is intended, can be quickly identified from the lighted signal lamp. In order to prevent delay of messages subsequently stored in the intermediate relay unit, the stalled message may be transferred to an auxiliary relay unit.

Auxiliary relay units.—The auxiliary relay or intercepting-storing units are structurally similar to the intermediate relay units. In the system illustrated, one auxiliary unit is installed in each group of intermediate relay units and each has access to the same secondary trunk lines as the associated intermediate units. Thus auxiliary relay unit AR_1 (Fig. 22) is included in group 1 of intermediate relay units, unit AR_2 in group 2 and unit AR_3 in group 3.

The trunk lines ATL_1, ATL_2 and ATL_3 hereinafter called auxiliary trunk lines, incoming to the auxiliary relay units, are not accessible directly to other relay units of the exchange but terminate at the supervisory switchboard in plug ended cords indicated generally at **675** (Fig. 31). The plugs may be of any preferred type capable of interconnection with jacks JK_1 to JK_5 of the bus circuits leading from the intermediate relay units. As before explained, the bus circuits are normally connected to the secondary trunk lines by normally closed jack switches. When one of the plugs **675** is inserted in a jack, the jack switch is opened and the auxiliary unit is connected to the bus circuit terminating at that jack for receiving a message from the intermediate relay unit. The secondary trunk line terminating at

the jack is disconnected from the bus circuit by the opening of the jack switch.

When the auxiliary relay unit is connected up in the above manner, transfer of the message from the intermediate unit is initiated in the usual way by the associated time assigner ST. For starting the time assigner, negative battery potential through closed availability switch 619 of the connected auxiliary relay unit AR_1, AR_2 or AR_3 is applied over the upper prong of the plug 675 to bus conductor 336. Closure of the switch 335 at the intermediate relay unit completes the starting circuit. The availability switch 619 had previously been closed mechanically by actuating means like those for closing the switches 613 and 311 shown in Fig. 15, and completes a circuit for lighting a signal lamp 633 (Fig. 31) at the switchboard to indicate availability of the auxiliary relay unit; the operator had therefore been apprised by the lighted lamp of the availability of the auxiliary unit.

Like the other relay units of the system, each auxiliary unit has a pair of switches 306 and 307 closed to return the O. K. signal when test signals are properly received and recorded. A full storage stop switch 546' interrupts transmission temporarily in case of a full storage condition. The full storage condition is indicated at the switchboard SB by lighting of a signal lamp 303 (Fig. 30).

Retransmission of the message from the auxiliary relay unit to a terminal relay unit is effected in the same manner as the transfer from an intermediate relay unit except for the selection of the trunk line leading to the terminal unit. It will be recalled that the transmitters of the intermediate relay units discard the directing signal used to select a trunk line. This occurs when a message is transferred to an auxiliary relay unit so the stored message is lacking in a directing signal. However, the routing of the message is determined automatically as an incident to the interconnection, by means of a transmitting plug 632, of the auxiliary unit with the terminal unit to receive the message. For this purpose the selector bars of the auxiliary unit are arranged to be released selectively by selector magnets individual to the respective bus circuits of the secondary trunk lines which magnets are energized by battery potential applied to the jack by a contact 675_a of the plug. These magnets are energized selectively in accordance with the particular jack into which the plug 632 of the auxiliary unit cord is inserted.

Referring more particularly to Figs. 22, 25 and 28, the auxiliary units, as herein shown, are provided with selector magnets SM_{13}, SM_{14}, SM_{15}, SM_{16}, and SM_{17} associated respectively with the secondary trunk line busses IB_1 to IB_5. One terminal of each magnet is connected by a conductor 676_a with a separate contact of the corresponding one of the jacks JK_1 to JK_5. As will be seen by referring to Fig. 31, each plug 632 is provided with prongs for engaging a plurality of the jack contacts but only one of these prongs is active namely the prong 675_a which is connected to negative battery. Thus when the calling plug for the auxiliary unit AR_1 is inserted in a selected jack, a circuit is closed for one of the selector magnets of that auxiliary unit. Similarly, insertion of the calling plug for the auxiliary unit AR_2 energizes a magnet of the unit AR_2 and insertion of the calling plug for the unit AR_3 energizes a magnet for the unit AR_3. In this way proper coordination of the intermediate relay unit, auxiliary relay unit and terminal relay unit is obtained. Let us suppose that a message intended for terminal unit TR_2 is blocked in the intermediate relay unit IR_1 due to a trouble condition of terminal unit TR_2 or its associated line and it is desired to remove this message from unit IR_1 so that subsequent messages stored in that unit (if directed to other terminal units) may proceed on their way. We may assume that the particular trouble condition is the inability of availability contact 619 to close. Assume further that the auxiliary relay unit AR_1 is idle and available to receive the blocked message, the uppermost lamp 633 (Fig. 31) will be lighted. The attendant notes the lighted lamp and inserts top plugs 675 and 632 (Fig. 31) into jack JK_2; this causes the trunk IB_2 to be disconnected from the terminal unit TR_2 and connected instead to the auxiliary unit AR_1. Upon the connection of trunk IB_2 to the auxiliary relay unit AR_1 a circuit is completed through the availability switch 619 and storage control switch 371_a of the auxiliary relay unit AR_1, trunk ATL_1, upper terminal of plug 635 and jack JK_2, contacts 335 and 337 and intermediate relay unit IR_1 over conductor 338 to the associated plunger magnet of time assigner ST_1. Upon the assignment of this trunk by the time assigner in response to the operation of the plunger magnet the J-cam shaft progresses through the test position to the transmitting position and the message is transmitted into the auxiliary relay unit AR_1. In so transmitting the message the unit IR_1 or any other unit adds the class of message signal to the head end of the message in the same manner as when it transmits directly to a terminal unit. At the end of the message the end-of-message signal is transmitted from unit IR_1 to auxiliary unit AR_1 and stored in the storage chain. The end-of-message signal, upon being transmitted by the intermediate relay unit IR_1 causes the J-cam shaft to be advanced from the No. 4 position to the No. 1 position. In advancing from the No. 4 to the No. 1 position the contacts ISL_2 of the relay unit IR_1 are opened. Thereafter the unit IR_1 is free to transmit the succeeding messages stored in its storage chain to appropriate terminal units provided they are not directed to the same place as the intercepted message (assuming unit TR_2 still be out of order). If a succeeding message is directed to unit TR_2 or some other out-of-order unit, it may be relayed to any other auxiliary unit which is available.

Let us now consider the message being stored in auxiliary unit AR_1. When the first character is stored in the chain and the chain advanced so that storage indicator or level switch leaves its zero position contacts 371_a will open and remain open until the storage indicator or level switch returns to its zero position. With contacts 371_a open the circuit from the availability switch is interrupted. Consequently, the auxiliary relay unit AR_1 will be unavailable for receiving additional messages as long as any portion of the previous message remains stored.

Upon storage of the message in the storage chain the associated transmitter will cause the chain to advance until the message approaches the transmitting point at which time the advance of the chain through the unit is interrupted. In the auxiliary relay unit the selecting mechanism controlled by signals stored in the chain has been replaced by magnets SM_{13} to SM_{17} as shown in Fig. 22. The manner in which these magnets control the switching mechanism is shown in Fig. 12. Under the assumed situation

the insertion of plug 682 in jack JK_2 has caused magnet SM_{14} to operate, consequently, as the J-cam shaft is advanced from the No. 1 position to the No. 2 position due to the approach of the stored message to the transmitting point the combination bar of the auxiliary relay unit AR_1 associated with trunk IB_2 will be released for the first portion of its movement and close the preliminary contacts extending a path to the time assigner circuit. The J-cam shaft will thereafter remain in its No. 2 position until the trunk IB_2 extends to some available relay unit and the time assigner functions to assign the auxiliary relay unit AR_1. So long as the plug 675 is in jack JK_2, the trunk IB_2 extends to the input side of auxiliary relay unit AR_1 which is unavailable so long as the message in question is stored in its storage unit, in other words, the circuits remain in the condition described as long as the upper plug 675 remains in jack JK_2.

After the trouble condition in the terminal relay unit TR_2 has been remedied, the plug 675 is withdrawn from the jack JK_2 whereupon the trunk IB_2 is reextended to the terminal relay unit TR_2. Since this relay unit is now in working order it tests available and completes a circuit through the auxiliary unit AR_1 to the time assigner ST_1. When the time assigner functions in response to this established circuit the J-cam shaft of the auxiliary relay unit will be advanced from its No. 2 rest position in the usual manner by way of a circuit including a switch 679 corresponding to the switches 337 of the intermediate relay unit AR_1.

In the present instance the auxiliary relay units are all controlled by the first class message time assigner ST_1 (Fig. 23), (any one or all of them could be controlled by second or third class time assigners), hence the plunger magnets PM_a for all auxiliary units are incorporated in this time assigner. In other words, the message proceeds to the terminal unit as a first class message even though it may be a second or third class message in a subsequent office reached over a trunk. Following the energization of the plunger magnet, the time assigner releases the J-cam shaft of the corresponding relay unit for movement from the No. 2 rest position in exactly the same way as in the case of intermediate relay units.

The auxiliary relay units transmit test signals in the same manner as other units and if these signals are properly received and recorded at the terminal relay unit, transmission of the message follows in the usual way. The end-of-message signal frees the auxiliary relay unit by releasing the J-cam shaft for movement to its No. 1 or normal rest position.

Emergency relay units.—Instead of transferring a stalled message to an auxiliary unit as above described, it may at times be desirable to remove the message from circulation for an extended period. This is particularly the case when the message is directed to a line known to be out or order or to one which is temporarily disconnected. For this purpose there is provided manual intercepting and printing means in the form of an emergency relay unit ER (Fig. 31) whose incoming trunk line ETL terminates in a plug ending cord 691. This plug is similar to the plugs 675 previously described and is adapted to be operably associated with the bus circuit jacks BJ to establish a transmission path from any intermediate relay unit to the emergency relay unit. Like the terminals units, the emergency unit has a simultaneous receiver and a start-stop transmitter. The latter is arranged to transmit directly to an ordinary printing telegraph receiver whose line relay 692 is shown diagrammatically in Fig. 31.

Messages removed from circulation in this manner may be returned to the exchange equipment through the medium of a keyboard operated transmitter ET (Fig. 30) which may be exactly like the transmitters supplied at the subscriber's stations. In the exemplary system this transmitter is connected by a calling line CL_e with a primary relay unit PR_6 identical in all respects with the primary units PR_2 to PR_5 previously described.

The emergency relay unit is preferably provided with an availability switch 619 and an availability magnet 620, a normally closed switch 623 and a relay 624 which is energized to open switch 623 when the trunk to the emergency unit is seized, and O. K. contacts 306 and 307, all these being similar to the corresponding elements of a unit such as the terminal unit TR_2 as previously described.

False address supervision.—It will be recalled that the selector mechanism of the intermediate relay units, when arranged for five unit code operation, is capable of selecting between thirty-one differently designated busses adapted for connection with the secondary trunk lines. In some instances, the full complement of busses may not be required, as for example, where there are less than thirty-one trunk lines or destination groups in use. The exemplary system, for example, shows only five equipped lines and four destination groups.

If through accident or mistake a calling subscriber inserts an address signal designating one of the unequipped busses, the message, of course, cannot be forwarded to the proper destination point by the automatic selector mechanism. In order to prevent loss of such messages and to avoid tying up later stored messages, there is provided a faulty address intercepting relay unit FAR in connection with the supervisory switchboard. This relay unit may be identical with the terminal relay units previously described and its incoming trunk line 695 is multiply connected with all unequipped bus circuits of the intermediate relay units. Thus, when any one of these busses not associated with an outgoing line is selected, the message is automatically transferred to the relay unit FAR in the same manner as messages are transferred to a terminal unit.

In the particular relay unit shown by way of illustration, the transmitter is arranged for start-stop transmission to a known type of telegraph printer TP whose line magnet 696 is shown in Fig. 30. Alternatively, the relay unit may be arranged to transmit to a device usually termed a reperforator which records the message in a tape punched with five-unit code. Printed reproduction of the message is preferred as it enables the attendant to check the message and notify the sender of the error in the address.

This provides a convenient method of delivering a message to a central office by incorporating in it an address unassigned to any path leading away from that office.

It will be apparent from the foregoing that the invention provides a telegraph system of novel and advantageous character operable to automatically relay messages in successive stages from calling stations to called stations without intervention of an operator or attendant but equipped

to intercept messages at the central station for recording thereat or for further transmission or both.

By reason of its advantageous construction and method of operation, the exchange equipment is well adapted for use with a known type of slow speed transmitting and receiving apparatus and yet is capable of relaying messages through the exchange system at high speed so that delays are reduced to a minimum. Blocked messages after interception and retransmission from an auxiliary unit are forwarded out of the office in which they have been intercepted as preferred messages. If such messages proceed over a trunk to other offices they proceed through those offices, unless intercepted again, according to their class of message designation, that is, they are forwarded in preferential order according to the class of service represented by the class of service designation incorporated with them. Moreover, novel means is provided for automatically testing the equipment prior to the transmission of each message so that delays or lost messages, due to equipment faults, are effectually avoided.

The invention also provides a novel method of and apparatus for distributing the traffic to the various equipment units so that each unit is enabled to handle its proportionate share of messages. Uniformity of distribution tends to speed up the passage of the messages through the exchange and it equalizes wear of the equipment. Traffic through the exchange may be supervised continuously and efficiently by a single attendant utilizing the improved supervisory equipment provided by the invention.

What is claimed is:

1. In a telegraph system, in combination, a group of message receiving and storing relay units each adapted to store in mechanical form a plurality of telegraph messages in which are incorporated directing signals indicating the destinations of the messages, means in each unit controlled by a directing signal for automatically selecting an available transmission path leading toward the indicated destination, an auxiliary relay unit associated with said group of units, and means for automatically establishing a transmission path from any storage unit to the auxiliary unit for the transfer thereto of messages for which no transmission paths leading toward the indicated destinations are available.

2. In a telegraph system, in combination, a group of message receiving and storing relay units, an auxiliary relay unit included in said group, a second group of message receiving and storing relay units, a supervisory switchboard, outgoing trunk lines accessible to all of the units of the first group and extending to the switchboard, incoming trunk lines extending from the switchboard to the individual units of the second group, means for connecting each outgoing trunk line with an incoming trunk line to establish a transmission path for the transfer of messages from the first group of units to the second group of units, an incoming trunk line extending from the switchboard to said auxiliary unit, said connecting means for the trunk lines being operable to connect any outgoing trunk line with the incoming trunk line for the auxiliary unit for the transfer thereto of blocked messages.

3. In a telegraph system, in combination, a group of message receiving and storing relay units, an auxiliary relay unit included in said group, a second group of message receiving and storing relay units, a supervisory switchboard, outgoing trunk lines accessible to all of the units of the first group and terminating in jack switches at the switchboard, incoming trunk lines for the units of the second group extending from said jack switches, said jack switches being normally closed to connect the outgoing trunk lines with the incoming trunk lines and thereby establish transmission paths from the units of the first group to the units of the second group, and an incoming trunk line for the auxiliary unit extending from a plug ended cord at the switchboard, said cord being operative when the plug is inserted in a jack to connect the outgoing trunk lines terminating at that jack with said last trunk line to establish a transmission path for transferring blocked messages from the units of the first group to the auxiliary unit, said plug acting to open the jack switch and thereby disconnect the incoming trunk line for the unit of the second group.

4. In a system for directing the course of a telegraph message from an originating point to a terminal point through a group of serially related ranks of message receiving and storing relay units, in combination, a group of serially related message receiving and storing units, means at the originating point for incorporating in the message signal combinations effective to select terminal paths leading from units of one rank to the proper unit of the next rank, and means for switching a message from a unit of one rank to a temporary storage unit of the same rank when the transmission to the unit of the next rank is blocked.

5. In a system for directing the course of a telegraph message from an originating point to a terminal point through a group of serially related stages of message receiving and storing relay units, in combination, means at the originating point for incorporating in the message signal combinations effective to select terminal paths leading from units of one stage to the proper unit of the next stage, an emergency relay unit, and trunking connections operative when the selecting signal of any message is mutilated to automatically direct the message to the emergency relay unit.

6. In a system for directing the course of a telegraph message from an originating point to a terminal point through a group of serially related message receiving and storing relay units arranged in ranks, in combination, means at the originating point for incorporating in the message signal combinations effective to select terminal paths leading from units of one rank to the proper unit of the next rank, a supplementary relay unit, trunking connections automatically operative when a faulty selecting signal is presented at a storing unit for directing the message to the emergency relay unit, a printing telegraph receiver, and means in said emergency relay unit for transmitting the message to said printing receiver.

7. In a telegraph system, in combination, a plurality of relay units for storing telegraph messages in mechanical form, means in each unit controlled by a portion of a message as stored for relaying the message selectively toward its destination, an emergency relay unit, timing apparatus for indicating the delay of a message due to the delay of the relay unit to be connected to an idle transmission path for the further transmission of the message, and manually operable

means for establishing a transmission path from any one of said storing units to the emergency unit for transfer thereto of messages delayed in the storage units.

8. In a telegraph system, in combination, a plurality of relay units for storing telegraph messages in mechanical form, means in each unit controlled by a portion of a message as stored for relaying the message selectively toward its destination, an emergency storage relay unit for storing messages in a form suitable for automatic retransmission, manually controlled means for causing said storage units to transfer delayed messages to said emergency relay units, means associated with the emergency relay unit for reproducing the transferred messages in visible form, and transmitting means for returning the messages to the storing units.

9. In a telegraph system, in combination, a plurality of relay units for storing telegraph messages in mechanical form, means in each unit controlled by a portion of a message as stored for relaying the message selectively toward its destination, an emergency relay unit, a supervisory switchboard, signal means at the switchboard operated automatically to indicate delay in the relaying of any of the messages from the storage units, means at the switchboard for switching delayed messages to the emergency relay unit, a printing telegraph receiver at the switchboard for reproducing the transferred messages in printed form, and a keyboard operated transmitter at the switchboard for returning the messages to the storage units.

10. In a telegraph switching exchange apparatus for transferring a message from one point to any one of a plurality of points selectively comprising, in combination, storing means for storing a succession of signals in mechanical form represented by a plurality of units each having either of two differentiating characteristics, selector mechanism operable by certain of said signals comprising directing signals to select a transmission path leading from said exchange to a station of address, intercept storage means to withdraw from one of said storage means and store a message or messages, operable means to cause storage of a message in said intercept storage means, and transmitting means to retransmit said messages thus stored to one of said storage means to cause its further direction over a path leading to its station of address.

11. In a telegraph system, a central switching station, a plurality of outlying stations, telegraph lines extending from said central station to said outlying stations, means at said central station for directing messages received from said outlying stations to other of said outlying stations in accordance with switching code combinations assigned to said outlying stations, and means responsive to switching code combinations not assigned to outlying stations for recording the message at the central switching station.

12. A telegraph system comprising a plurality of outlying stations, a central station, receiving apparatus local to said central station, means at all of said stations for transmitting telegraph messages, means for transmitting telegraph signals preceding each message designating a station for which the messages are intended, means at the central station responsive to station designating signals for directing messages to an outlying station designated by a given switching signal, and means responsive to other designating signals which do not designate any outlying station for causing the recording of said message on said local receiving apparatus.

13. A telegraph switching system comprising a switching station, a plurality of outlying stations which are represented by specified permutation code combinations, means at said switching station for directing the messages to said outlying stations in accordance with said preassigned code combinations, and means at said switching station responsive to switching code combinations not assigned to outlying stations for causing the receiving of the message thereat.

14. In a telegraph system, a switching station, a plurality of outlying stations, telegraph lines extending to said outlying stations, switching apparatus at said switching station for directing messages to said outlying stations in accordance with received telegraph signals preceding said messages, and manually operable means cooperating with said switching apparatus for causing said switching apparatus to automatically selectively direct all the messages directed to any line to be recorded at said switching station.

15. A telegraph system comprising a plurality of stations, a network of transmission channels interconnecting said stations, means at one or more of said stations for impressing upon said network a succession of code-representing currents comprising message codes preceded by address codes, at least some station being individually represented by an address code or codes, means controlled by the address code or codes of a station to direct message codes preceded thereby to the station designated thereby, an intercepter-recorder in said system, and means for directing to said interceptor-recorder all series of message codes not preceded by codes assigned to designated stations.

16. In a telegraph system, a switching station, a plurality of sources of messages each normally accompanied by address signals, a station of address for said messages, a plurality of paths having stages of storage and retransmission through said switching station over any one of which messages may be directed to said station of address, selective devices operated in accordance with the address signals for controlling direction of messages over said paths, a supplemental path including more stages of storage and retransmission than the others, and control means for automatically causing messages directed to said station of address to proceed thereto via said supplemental path.

17. In a system, including a switching station, for directing messages transmitted as currents representing code combinations in which each message has incorporated therewith routing code combinations representing a channel of transmission outgoing from said switching station, means including selective means automatically operative under control of said routing code combinations for directing messages selectively over one of said routes, a message recorder local to said station, and means including selective means operable under control of routing code combinations not representing a channel outgoing from said switching station for causing recording of said message by said recorder.

18. A telegraph exchange system, apparatus for transferring a message from one point to any one of a plurality of other points selectively comprising, in combination, storing means for storing a succession of signals in mechanical form represented by a plurality of units each having either of two differentiating characteristics, se-

lector mechanism operable under control of certain of said signals comprising directing signals to select a transmission path leading from said exchange toward a station of address, one of said storing means having a path or paths leading from it to a station of address selectable by certain of said signals, and supplemental means responsive to other directing signals attempting to control the direction of a message from said one storage means to automatically direct and automatically convey said message to said supplemental storage means.

19. An automatic message directing system comprising a plurality of instrumentalities wherein each instrumentality comprises means for storing a succession of signals in mechanical form represented by a plurality of units each having either of two differentiating characteristics, certain of said signals comprising message information and certain others in definite relation thereto comprising directing signals, a plurality of paths interconnecting said instrumentalities over which messages are transferred from one instrumentality selectively toward addresses represented by one or more of the directing signals, in combination with intercept means associated with certain of said instrumentalities responsive to false directing signals not representing any available path for automatically selecting an intercept path and automatically transferring the message thereto, and storage means associated with said intercept path for storing messages thus intercepted.

20. A telegraphic system comprising a transmitter of the storage controlled type associated

with storage means for storing successive code combinations comprising successive messages each of which messages is preceded by a code or codes for designating and selecting a path out of a possible plurality of paths outgoing from said transmitter over which its associated message is to be transmitted, selecting means for so selecting said path, said selecting mean when erroneously controlled being capable of making a selection for which no path exists, means including supplemental recording means operable upon making such a selection for which no such path exists for sending to said recording means from said transmitter, incidental to and under control of the making of such a selection, the message for which the erroneous selection has been made to free said selecting means for selecting a path and to free said transmitter for sending a following message.

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