

April 3, 1934.

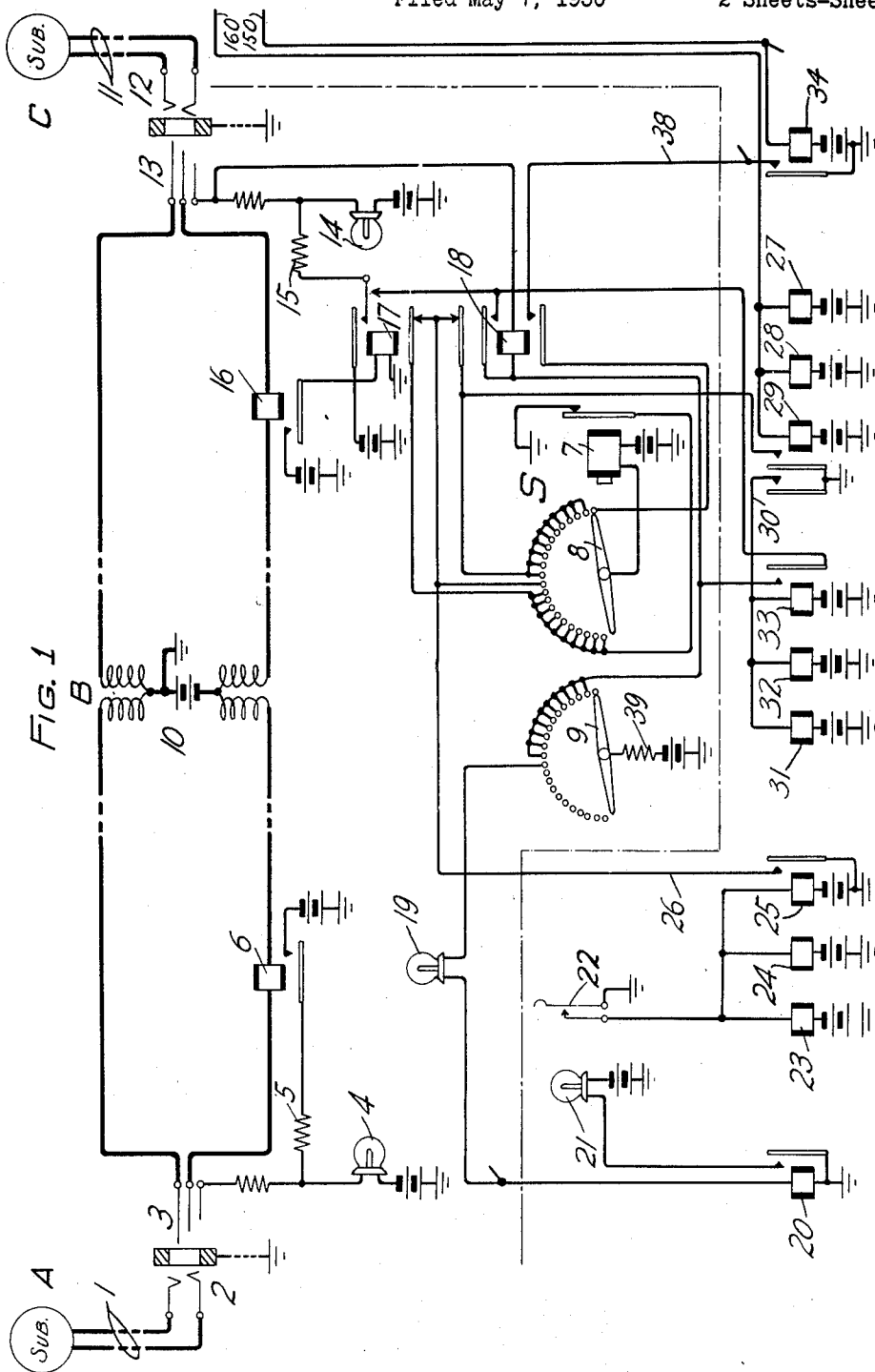
C. B. FOWLER ET AL.

1,953,474

TELEPHONE EXCHANGE SYSTEM

Filed May 7, 1930

2 Sheets-Sheet 1



INVENTORS: *C.B. FOWLER*
J.W. GOODERHAM
BY

BY

MOB Mc Kenney
ATTOR

ATTORNEY

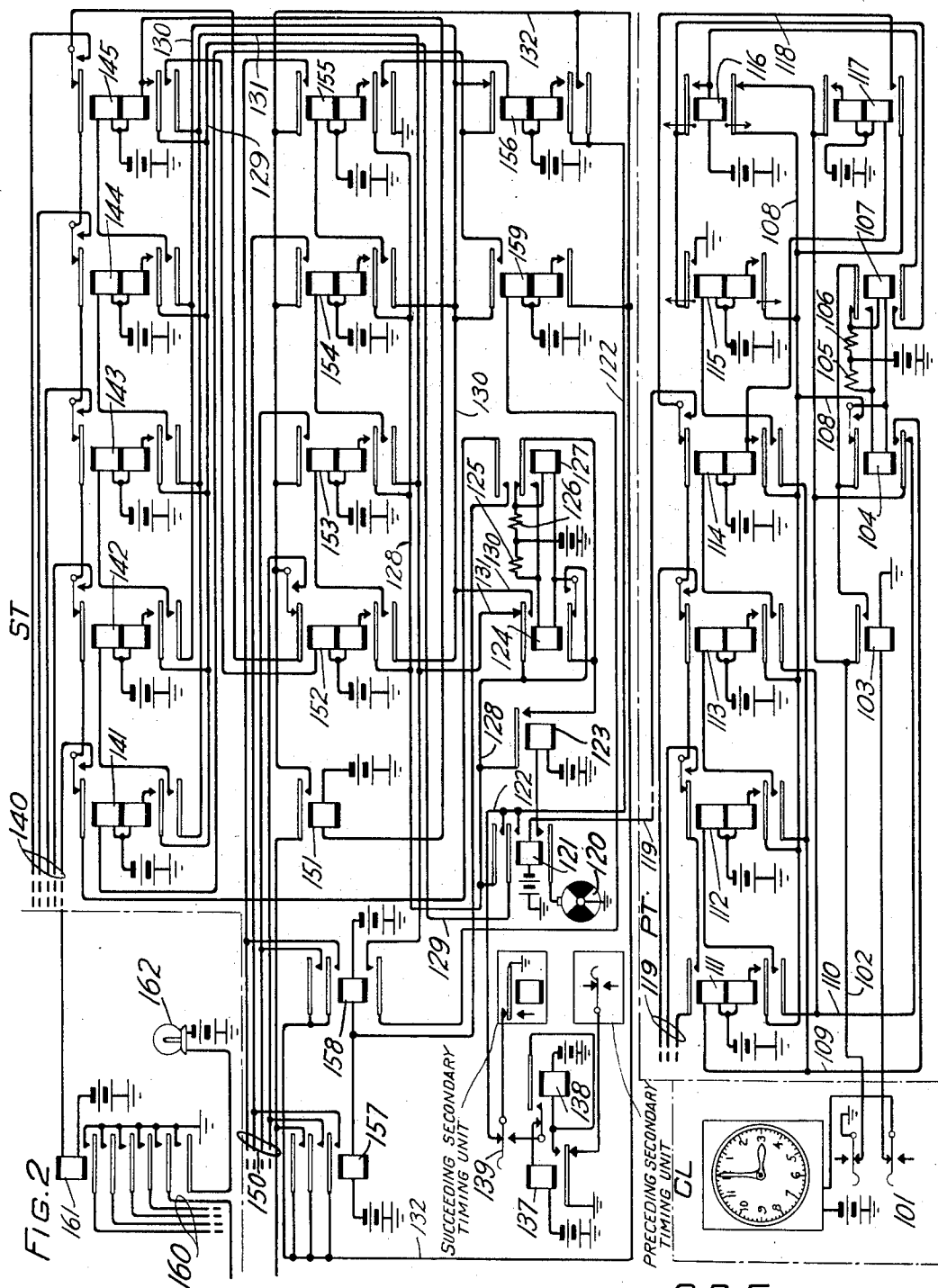
April 3, 1934.

C. B. FOWLER ET AL
TELEPHONE EXCHANGE SYSTEM

1,953,474

Filed May 7, 1930

2 Sheets-Sheet 2



INVENTORS:

C. B. FOWLER
J. W. GOODERHAM

BY

M. J. McHenry

ATTORNEY

UNITED STATES PATENT OFFICE

1,953,474

TELEPHONE EXCHANGE SYSTEM

Clarence B. Fowler, Queens Village, and John W. Gooderham, Larchmont, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application May 7, 1930, Serial No. 450,438

20 Claims. (Cl. 161—19)

This invention relates to telephone systems and particularly to systems in which the charges for service rendered to subscribers are based on the duration of the telephone calls.

5 The objects are to minimize the amount of equipment required at an operator's position for timing calls, to conserve valuable space at the position, to simplify the duties of the operator in attending to the calls, and to otherwise improve systems of this character.

10 It has been proposed heretofore to equip operators' positions with timing devices, one for each cord circuit, together with means for starting a timing device in operation when the called party answers, the timing device serving to measure a definite interval of time and to effect a signal at the end of the interval to attract the operator's attention. In order to guard against the false starting of the timing device by a momentary impulse, these previous systems have been arranged to allow a short interval immediately following the called subscriber's answer before the timing begins, and this interval will also precede each succeeding over-time period during the continuance of the conversation. It has also been proposed to employ individual keys for the cord circuits for controlling the operation of the timing devices.

30 According to the present invention, the objection to the recurrence of this free interval throughout the entire conversation has been overcome by means of a system which provides for such an interval when the called party first answers but eliminates it at the beginning of each succeeding over-time period. This end is accomplished by means of a timing mechanism which produces a series of periodic timing impulses which cause the operation of a time-measuring device. The said mechanism also produces a starting impulse before and one after each timing impulse. When the conversational circuit is first established, the measurement of time is started by the starting pulse which follows the next timing impulse, whereas for succeeding over-time periods the timing is started by the pulse that precedes the corresponding timing impulse.

40 According to another feature of the present invention improvements have been effected in systems of this character by means of an arrangement in which a single key is provided at the operator's position common to all the timing devices; this key serves to selectively release any timing device that has completed the measurement of an interval without disturbing other devices which are still in the process of timing a

call. By the use of a single key, valuable space in the operator's keyboard is conserved and her duties in supervising various connections are considerably lightened.

The drawings show schematically, one embodiment of this invention.

Figure 1 shows a subscriber's station at A connected by the line 1 to an answering jack 2 at an operator's position of a manually operated switchboard. Another subscriber's station at C is shown connected by the line 11 to the jack 12. Each position of the switchboard is provided with a group of cord equipments for use in extending connections from calling to called subscribers' stations. Each of these cord equipments, one of which is shown at B includes the answering cord and plug 3, the repeating coil 10, the calling cord and plug 13, the supervisory relays 6 and 16, and the lamps 4 and 14. Additional equipment associated with each cord equipment for use in measuring and indicating elapsed periods of maintained connection includes the auxiliary relay 17, the sleeve relay 18, the signal lamp 19 and the rotary switch S with its stepping magnet 7 and its brushes 8 and 9. The brushes of switch S are shown in their normal position in contact with the first terminal of their respective banks. The release of magnet 7 after each operation is effective to advance brushes 8 and 9 one step in a counter clockwise direction. Each operation of magnet 7 may, therefore, be said to advance the switch one position and reference to a particular position of switch S in the following description indicates that the brushes are in contact with corresponding terminals.

Each operator's position is also equipped with a lamp 21, a release key 22, a relay 20, a pick-up relay 34, release relays 23, 24 and 25, timing relays 27, 28 and 29, and with auxiliary timing relays 31, 32 and 33. Each of relays 23, 24 and 25 is equipped with a number of front contacts (only one being shown), one for each cord equipment of the position with which the relays are associated. Each of relays 27, 28 and 29 is also equipped with a number of front contacts (only one being shown), one for each cord equipment. And, in like manner, each of relays 31, 32 and 33 is equipped with a number of front contacts (only one being shown), one for each cord equipment. Relay 29 is provided with an additional front contact for operating relays 31, 32 and 33. Pick-up relay 34 is also equipped with contacts in addition to the one shown, each contact being common to three cord equipments.

Figure 2 shows, schematically, equipment for supplying timing impulses to all of the "A" operator's positions. This equipment includes the clock circuit shown schematically at CL; two primary timing circuit units, one of which is shown at PT; two or more secondary timing circuit units, one of which is shown at ST; and a number of group relays, which are represented by the one shown and designated 161. A primary transfer key 101 is provided for transferring the clock circuit unit from one primary timing circuit unit to the other, only one primary unit being in use at a time; this arrangement insures a continuous supply of timing impulses and divides the wear of the contacts of the timing relays. As many secondary timing circuit units are provided as are required; in the office being considered there is one unit for each 25 positions but at least two units are furnished in all cases. A secondary transfer key, shown in part as key 139, is provided with each secondary unit so that the positions associated with any one of these units may be switched to the preceding secondary timing unit in case the unit in question fails to operate properly. The aforementioned primary transfer key is also arranged to transfer the secondary timing circuit units, from one primary timing unit to the other, at the same time that it transfers the clock circuit. Each group relay, such as 161, is common to a number of positions; in the office being considered, one relay is provided for each 5 positions.

The operation of the timing equipment will now be explained beginning with the operation of the primary timing circuit unit PT. With key 101 in the position shown, the clock circuit CL closes a circuit for operating relay 103 once every six seconds, the closure being maintained for approximately $\frac{1}{16}$ of a second. Assume that all other relays of unit PT are normal at the time that relay 103 is first operated. The first operation of relay 103 closes a circuit for operating relay 104; this circuit may be traced from battery through resistance 105, winding and back contact of the continuity spring of relay 104, contacts of relay 103, and through conductor 102, to ground at key 101. In operating, relay 104 closes a locking circuit through the front contact of its continuity spring, through conductor 108, and through the lower contacts of relay 116, to ground on conductor 102. A circuit is also closed from battery through resistance 106, winding of relay 107, front contact of the continuity spring of relay 104, conductor 108, lower contacts of relay 116, to the ground on conductor 102; but relay 107 does not operate since its winding is short-circuited through its own back contact and the contacts of relay 103 as long as relay 103 remains operated. When relay 103 releases, the short circuit is opened and relay 107 operates in the circuit through the front contact of the continuity spring of relay 104.

When relay 103 operates a second time, six seconds after its first operation, relay 104 releases since its winding is short-circuited through the upper front contact of relay 107 and the front contact of relay 103. With relay 104 released, a circuit is closed for holding relay 107 until relay 103 releases; this circuit may be traced from battery through resistance 106, winding of relay 107, back contact of the continuity spring of relay 104, and through the front contact of relay 103, to ground on conductor 102. When relay 103 releases, after its second operation, relay 107 releases. Thus relay 103 operates and releases once

every six seconds; and relay 104 operates and releases once every 12 seconds.

The first operation of relay 104 as hereinbefore described also closes a circuit for operating relay 111; this circuit may be traced from battery through the upper winding of relay 111, conductor 109, lower front contact of relay 104, to ground on conductor 102. In operating, relay 111 closes a locking circuit from battery through its lower winding and inner lower front contact, conductor 108, lower contacts of relay 116, to ground on conductor 102. When relay 104 releases, six seconds after its first operation, a circuit is closed for operating relay 112; this circuit may be traced from battery through the upper winding of relay 112, outer lower front contact of relay 111, conductor 110, and through the lower back contact of relay 104, to ground on conductor 102. In operating, relay 112 closes a locking circuit from battery through its lower winding and inner lower front contact, conductor 108, lower contacts of relay 116, to ground on conductor 102. When relay 104 operates a second time, 6 seconds after its first release, a circuit is closed for operating relay 113; this circuit may be traced from battery through the upper winding of relay 113, outer lower front contact of relay 112, conductor 109, lower front contact of relay 104, to ground on conductor 102. In operating, relay 113 closes a locking circuit from battery through its lower winding and inner lower front contact, conductor 108, lower contacts of relay 116, to ground on conductor 102. When relay 104 releases, six seconds after its second operation, a circuit is closed for operating relay 114; this circuit may be traced from battery through the upper winding of relay 114, outer lower front contact of relay 113, conductor 110, and through the lower back contact of relay 104, to ground on conductor 102. In operating, relay 114 closes a locking circuit from battery through its lower winding and inner lower front contact, conductor 108, lower contacts of relay 116, to ground on conductor 102. Relay 114 also closes a circuit for operating relay 117 since the winding of relay 117 is connected in parallel with the lower winding of relay 114. In operating, relay 117 closes a locking circuit from battery through its upper winding and upper front contact, to ground on conductor 102. When relay 104 operates a third time, 6 seconds after its second release, a circuit is closed for operating relay 115; this circuit may be traced from battery through the upper winding of relay 115, outer lower front contact of relay 114, conductor 109, lower front contact of relay 104, to ground on conductor 102. In operating, relay 115 closes a locking circuit from battery through its lower winding and front contact, conductor 108, lower contacts of relay 116, to ground on conductor 102. When relay 107 operates, $\frac{1}{16}$ of a second after the third operation of relay 104, a circuit is closed for operating relay 116; this circuit may be traced from battery through the winding of relay 116, lower contacts of relay 107, and through the upper contacts of relay 115, to ground. In operating, relay 116 closes a locking circuit through its winding and upper contacts to the same ground. Relay 116 also disconnects conductor 108 from conductor 102, thereby causing the release of relays 111, 112, 113, 114 and 115 as soon as relay 104 releases. When relay 115 releases the locking circuit of relay 116 is opened and relay 116 releases. Relay 117 remains operated until transfer key 101 is operated. The

described cycle of operation is repeated once every thirty seconds.

When relay 117 operates, as hereinbefore described, the ground on conductor 102 is extended through the lower contacts of relay 116, conductor 108, lower contacts of relay 117, to the continuity contact spring of relay 114 to render the operation of timing relays 111, 112, 113 and 114 thereafter effective to supply timing impulses over conductors 119 to the start relays (such as relay 121) of the secondary timing circuit units. Thus the first operation of relay 114 is effective to supply a timing impulse over conductor 119 to operate start relay 121 of the secondary timing unit ST; but the preceding operation of each of relays 111, 112 and 113 is ineffective to supply timing impulses since relay 117 has not yet operated. The circuit for operating start relay 121 of the secondary timing circuit unit ST may be traced from ground on conductor 102, through the lower contacts of relay 116, conductor 108, lower contacts of relay 117, conductor 118, upper front contact of relay 114, the upper one of conductors 119, and through the winding of relay 121, to battery. Since relay 114 locks under control of relay 116, relay 121 is held operated for six seconds; that is until relay 116 operates.

The second operation of relay 111 closes a circuit for operating the start relay (not shown) of another secondary timing circuit unit; this circuit may be traced from ground on conductor 102, lower contacts of relay 116, conductor 108, lower contacts of relay 117, conductor 118, back contact of relay 114, back contact of relay 113, back contact of relay 112, and through the upper front contact of relay 111, over the lower one of conductors 119 to the associated start relay (not shown). This circuit is closed until relay 112 operates six seconds later, at which time the start relay associated with relay 111 releases and the ground on conductor 118 is connected through the back contacts of relays 114 and 113, and through the upper front contact of relay 112, over the next to the lower one of conductors 119 to operate the start relay (not shown) of a third secondary timing circuit unit. When relay 113 operates six seconds later, the start relay associated with relay 112 releases and the ground on conductor 118 is connected through the back contact of relay 114 and upper front contact of relay 113, over the next to the upper one of conductors 119 to operate the start relay (not shown) of a fourth secondary timing circuit unit. When relay 114 operates (the second time) six seconds later, the start relay associated with relay 113 releases; and start relay 121 is again operated as hereinbefore described at the first operation of relay 114. Thus each succeeding operation of relays 111, 112, 113, and 114 causes the operation of the start relay of the associated secondary timing circuit unit and the start relays of the 4 units are successively operated at intervals of six seconds, the release of each of these start relays immediately preceding the operation of the next. Each start relay is therefore operated once every 30 seconds, remaining operated for six seconds.

The primary timing circuit unit is arranged so that the first operation of relays 111, 112 and 113 are not effective to operate the associated start relays in order that operation of the primary transfer key 101 will not, in any case, cause the start relay of any secondary unit to be operated more frequently than once every thirty seconds. At the time of the operation of key 101 and the transfer of conductors 119 from one pri-

mary unit to the other, the interval between the release of a start relay and its succeeding operation may be extended, up to 24 seconds beyond the usual 24 seconds.

The operation of the secondary timing circuit unit ST will now be explained. At the time that start relay 121 is operated, as hereinbefore described, all other relays of the secondary unit ST are assumed to be normal. With relay 121 operated, conductors 128 and 129 are connected through front contacts of relay 121, conductor 122, and through contacts of the secondary transfer key 139 to ground in the succeeding secondary timing unit at the back contact of the relay corresponding to relay 137; and the winding of relay 123 is connected through a front contact of relay 121 to interrupter 120. The interrupter 120 extends this connection to ground 120 times per minute, the duration of each such connection being $\frac{1}{120}$ of a second. During the six seconds that relay 121 is operated, relay 123 is, therefore, operated and released once every half second, the interval between each operation and release being $\frac{1}{120}$ of a second.

Each operation of relay 123 extends the aforementioned ground over conductors 122 and 128, through the front contact of relay 123, to relays 124 and 127. Relays 124 and 127 are arranged to operate under control of relay 123 in the same manner that relays 104 and 107 (of unit PT) operate under control of relay 103 as hereinbefore described; the resistances 125 and 126 correspond to the resistances 105 and 106. Thus the first operation of relay 123 causes the operation of relay 124; and the release of relay 123, $\frac{1}{120}$ of a second later, causes the operation of relay 127. The second operation of relay 123, $\frac{1}{2}$ second after its first operation, causes the release of relay 124; and the release of relay 123, $\frac{1}{120}$ of a second later, causes the release of relay 127. In this manner the operation and release of relay 123 once every half second is effective to cause the operation and release of relay 124 once every second, the release of relay 124 in each case occurring $\frac{1}{2}$ second after its operation.

The first operation of relay 124 closes a circuit for operating timing relay 141; this circuit may be traced from battery through the upper winding of relay 141, back contact of relay 156, conductor 130, upper front contact of relay 124, conductor 128, outer upper front contact of relay 121, to ground on conductor 122. In operating, relay 141 closes a locking circuit from battery through its lower winding and inner lower front contact, conductor 129, inner upper front contact of relay 121, to ground on conductor 122. The release of relay 124, $\frac{1}{2}$ second after its first operation, closes a circuit for operating timing relay 142; this circuit may be traced from battery through the upper winding of relay 142, outer lower front contact of relay 141, conductor 131, upper back contact of relay 124, conductor 128, to ground on conductor 122. In operating, relay 142 closes a locking circuit from battery through its lower winding and inner lower front contact, over conductor 129, to ground on conductor 122. The second operation of relay 124, $\frac{1}{2}$ second after its first release, closes a circuit for operating timing relay 143; this circuit may be traced from battery through the upper winding of relay 143, outer lower front contact of relay 142, conductor 130, upper front contact of relay 124, over conductor 128, to ground on conductor 122. In operating, relay 143 closes a locking circuit from battery through its lower winding and inner lower

front contact, over conductor 129, to ground on conductor 122. The release of relay 124, $\frac{1}{2}$ second after its second operation, closes a circuit for operating timing relay 144; this circuit may be traced from battery through the upper winding of relay 144, outer lower front contact of relay 143, conductor 131, upper back contact of relay 124, over conductor 128, to ground on conductor 122. In operating, relay 144 closes a locking circuit from battery through its lower winding and inner lower front contact, over conductor 129, to ground on conductor 122. The third operation of relay 124, $\frac{1}{2}$ second after its second release, closes a circuit for operating timing relay 145; this circuit may be traced from battery through the upper winding of relay 145, outer lower front contact of relay 144, conductor 130, upper front contact of relay 124, over conductor 128, to ground on conductor 122. In operating, relay 145 closes a locking circuit from battery through its lower winding and inner lower front contact, over conductor 129 to ground on conductor 122.

Since the winding of pick-up relay 151 is permanently connected in parallel with the locking winding of relay 145, the aforementioned operation of relay 145 also causes the operation of relay 151. The release of relay 124, $\frac{1}{2}$ second after its third operation, closes a circuit for operating pick-up relay 152; this circuit may be traced from battery through the upper winding of relay 152, outer lower front contact of relay 145, conductor 131, upper back contact of relay 124, over conductor 128, to ground on conductor 122. In operating, relay 152 closes a locking circuit from battery through its lower winding and inner lower front contact, over conductor 128, to ground on conductor 122. The fourth operation of relay 124, $\frac{1}{2}$ second after its third release, closes a circuit for operating pick-up relay 153; this circuit may be traced from battery through the upper winding of relay 153, outer lower front contact of relay 152, conductor 130, upper front contact of relay 124, conductor 128, to ground on conductor 122. In operating, relay 153 closes a locking circuit from battery, through its lower winding and inner lower front contact, over conductor 128, to ground on conductor 122. The release of relay 124, $\frac{1}{2}$ second after its fourth operation, closes a circuit for operating pick-up relay 154; this circuit may be traced from battery, through the upper winding of relay 154, outer lower front contact of relay 153, conductor 131, upper back contact of relay 124, over conductor 128, to ground on conductor 122. In operating, relay 154 closes a locking circuit from battery through its lower winding and inner lower front contact, over conductor 128, to ground on conductor 122. The fifth operation of relay 124, $\frac{1}{2}$ second after its fourth release, closes a circuit for operating pick-up relay 155; this circuit may be traced from battery through the upper winding of relay 155, outer lower front contact of relay 154, conductor 130, upper front contact of relay 124, over conductor 128, to ground on conductor 122. In operating, relay 155 closes a locking circuit from battery through its lower winding and inner lower front contact, over conductor 128, to ground on conductor 122.

The operation of relay 155 also closes an obvious circuit through the upper winding of relay 156. Relay 156 operates and closes a locking circuit from battery through its lower winding and inner lower front contact to ground on conductor 122. Relay 156 opens the circuit through the operating winding of timing relay 141 so that succeeding operations of relay 141

are dependent upon relay 159 being operated. Relay 156 also extends the connection from ground over conductor 122, through the outer lower front contact of relay 156, to conductor 132 and through the upper make contacts of relays 151, 152, 153, 154 and 155 to conductors 150; but this ground is ineffective to start the timing of any connection since none of the timing conductors 140 are connected to ground, as hereinafter described, at this time. The ground connected to conductor 132, is however, effective to start timing on all established connections when timing relays 141, 142, 143, 144 and 145 and pick-up relays 151, 152, 153, 154 and 155 are reoperated, 30 seconds after the initial operation, as controlled by the primary timing unit.

The release of relay 121 six seconds after its first operation, causes the release of the timing relays 141, 142, 143, 144 and 145 and the release of the pick-up relays 151, 152, 153, 154, and 155. The interrupter 120 is disconnected from the winding of relay 123 so that further operation and release of relays 124 and 127 is prevented until relay 121 is again operated, six seconds later. Relay 156 does not release being directly locked to the ground on conductor 122 under control of the secondary transfer key 139 and the relay corresponding to relay 137 in the succeeding secondary timing unit.

The second operation of start relay 121, thirty seconds after its first operation, again connects relay 123 to interrupter 120, relays 124 and 127 being thereby again operated and released in the manner hereinbefore described. On account of relay 156 being operated, the first operation of relay 124 does not cause the operation of timing relay 141 as it did the first time relay 121 operated. But the first operation of relay 127 now causes the operation of relays 157 and 158 in a circuit which may be traced from battery through their windings in parallel, through the outer upper front contact of relay 127, through the upper back contacts of relays 141, 142, 143, 144, 145 and 152 over conductor 132 and through the outer lower front contact of relay 156, to the ground on conductor 122. In operating, relays 157 and 158 connect the ground on conductor 132 to each of the pick-up leads 150 which extend to the pick-up relays, such as 34 shown in Fig. 1, at the A operator's position. The operation of relay 34 and the corresponding relays at other positions is not yet effective to start timing since ground has not as yet been extended over timing conductors 140 to operate the group relay 161 and the other group relays to which these conductors are connected.

The release of relay 124, after relay 158 has operated, closes a circuit for operating relay 159; this circuit may be traced from battery through the upper winding of relay 159, lower front contact of relay 158, conductor 131, and through the upper back contact of relay 124, over conductor 128, to ground on conductor 122. In operating, relay 159 closes a locking circuit through its lower winding and front contact, over conductor 132 and through the outer lower front contact of relay 156, to ground on conductor 122. Relay 159 also extends conductor 130, through its upper front contact to the upper winding of timing relay 141, so that the next operation of relay 124 will be effective to operate relay 141. The release of relay 127, one half a second after its operation, causes the release of relays 157 and 158 and the consequent disconnection of the ground over conductor 132 from pick-up conductors 150. In op-

erating relay 141 connects ground to one of conductors 140 thereby operating group relay 161. The circuit for operating relay 161 may be traced from battery through its winding, upper front contact of relay 141, upper back contacts of relays 142, 143, 144, 145 and 152, over conductor 132 and through the outer lower front contact of relay 156 to ground on conductor 122. Relay 141 locks through its lower winding as hereinbefore described. Thereafter relays 142, 143, 144, 145, 151, 152, 153, 154 and 155 operate in succession in the manner hereinbefore described. The operation of relay 142 opens the circuit for group relay 161 and closes a circuit over another of conductors 140 to another group relay. Thus the operation of timing relays 141, 142, 143, 144 and 145 successively closes circuits over conductors 140 to each of the group relays such as the relay 161. The group relays are, therefore, successively operated at half second intervals, each one being released at the time that the next one operates. The operation of each group relay connects ground to conductors such as 160, each of which extends to one of the "A" operators' positions and connects to the windings of position relays such as 27, 28, and 29 shown in Figure 1. The operation of pick-up relays 151, 152, 153, 154 and 155 is effective to successively extend ground from conductor 132 over conductors 150 to the pick-up relays such as 34 at the "A" operators' positions; thus the operation of relay 151, two seconds after the operation of group relay 161, closes the circuit for operating the pick-up relays 34 at a first group of positions; the operation of relay 152, one half second later, closes the circuit for operating the corresponding pick-up relays at another group of positions; and similarly at one half second intervals ground is extended over the other conductors 150 to operate the pick-up relays at each of the remaining groups of positions. The circuit for these pick-up relays is maintained over all of the conductors 150 until start relay 121 releases, at which time all of relays 141, 142, 143, 144, 145, 151, 152, 153, 154 and 155 are released.

Successive operations of the start relay 121, every thirty seconds, cause relays 157 and 158 to simultaneously connect ground to all of the pick-up conductors 150, these connections being maintained for one half a second; to then successively connect ground to each of timing conductors 140, each of these connections being maintained for one half a second; and to then successively connect ground to each of the pick-up conductors 150, each of these connections being established two seconds after ground has been connected to the corresponding one of the timing conductors 140.

Each secondary timing circuit unit continues to repeat the above described cycle of operations until the associated secondary transfer key, such as key 139, is operated on account of a trouble condition having developed or for the purpose of testing the transfer feature. The operation of key 139 disconnects ground from conductor 122 so as to release all of the relays in the unit ST and to prevent the further operation of this unit in supplying ground impulses over conductors 140 and 150. The operation of key 139 also closes a circuit for operating relay 137; this circuit may be traced from ground at the back contact of the corresponding relay in the succeeding secondary timing unit, front contact of key 139 and back contact of relay 138, through the winding of relay 137, to battery. When relay 137 operates the ground supply for the preceding

secondary timing unit is opened at the back contact of relay 137 so that the preceding timing unit is also temporarily rendered ineffective to supply ground impulses to the associated operators' positions. Relay 137 also closes a circuit for operating relay 138 which locks through its front contact and the front contact of key 139 to the ground in the preceding secondary timing unit. In operating, relay 138 causes the release of relay 137 thus reconnecting the ground at its armature and back contact for the preceding secondary timing unit. The preceding unit again begins to operate as hereinbefore described for unit ST, the first cycle of operations being ineffective to transmit impulses. Succeeding cycles of this preceding timing unit again supply ground impulses over its own conductors 140 and 150 and also supply ground impulses over the conductors 140 and 150 of the timing unit which has been transferred by the operation of key 139. It is apparent, therefore, that relays 137 and 138 prevent shortening of the period between the timing impulses connected to conductors 140 and the succeeding pick-up impulses connected to conductors 160, at the time that the positions associated with one timing unit are transferred to the succeeding timing unit, even though the two timing units were not operating in synchronism; and in this way these relays prevent a shortening of the conversation period for which a unit charge is made, it being considered more desirable to undercharge than to overcharge a calling subscriber.

Having described the operation of the timing circuits whereby ground impulses are supplied over conductors 150 and 160 to the A operator's position, we will now consider the timing of a given connection which is assumed to have been completed from the calling station A through cord equipment B to the called station C.

With the receiver removed from the switch-hook at station A and with the plug 3 inserted in jack 2, the supervisory relay 6 operates. In operating relay 6 prevents lamp 4 from lighting by connecting the resistance 5 in parallel with the lamp. When the plug 13 is inserted into jack 12, the supervisory lamp 14 is lighted. A ringing key (not shown) is operated to signal the subscriber at station C and when the receiver at this station is removed from the switch-hook the supervisory relay 16 operates. The circuit for operating relay 16 may be traced from battery, through the lower right-hand winding of repeating coil 10, winding of relay 16, ring conductors of the plug 13 and jack 12 over the line 11 and through the telephone at station C, back through the tip conductors of jack 12 and plug 13, and through the upper right-hand winding of repeating coil 10 to ground. Relay 16 closes a circuit for operating the auxiliary relay 17. In operating relay 17 extinguishes lamp 14 by connecting the resistance 15 in parallel with the lamp.

The further operation of the cord equipment B depends upon timing impulses supplied from the timing equipment. As soon as ground is connected to timing conductors 160 by the operation of group relay 161, relays 27, 28 and 29 are operated, in an obvious circuit. The operation of relay 29 closes a circuit for operating relays 31, 32 and 33. Relays 31, 32 and 33 cause the operation of relays such as 18 in all of the cord circuits which are in use at one position and in which the relay such as 17 has operated since the preceding release of relays 31, 32 and 33. The

circuit for operating relay 18 may be traced from battery through the upper front contacts of relay 17, front contact of relay 33, winding of relay 18, sleeve of the plug 13, to ground at the sleeve of jack 12. Relay 18 locks through its inner upper front contact under the control of relay 17 to the same ground. Two seconds later ground is connected, by the operation of relay 151 in the secondary timing unit, to conductor 150 thereby causing the operation of pick-up relay 34. Relay 34 connects ground over conductors such as 38, through the lower front contacts of all relays such as 18 which were first operated two seconds earlier and which have remained operated, to advance the associated meter control switches such as S from their normal position. Thus the operation of relay 34 closes a circuit, for the magnet of switch S, which may be traced from battery through the winding of the magnet 7, brush 8 in the first or normal position, lower front contact of relay 18, to ground at relay 34. Should the operation of relay 16 be temporary and relay 17 be released before relay 34 operates, relay 18 is also released to prevent the advance of switch S. When the pick-up relay 34 releases, the release of magnet 7 advances the brushes of switch S to its second position. In this position a circuit is closed to hold relay 18 operated until switch S has counted off the first period of conversation even though relays 16 and 17 should release due to the receiver being replaced upon the receiver hook at the called station C; this circuit may be traced from battery through resistance 39, brush 9 in any of positions 2 to 11 inclusive, winding of relay 18, sleeve of plug 13, and sleeve of jack 12 to ground.

Switch S is now advanced one step each time relays 27, 28 and 29 are thereafter operated and released, that is once every thirty seconds. A period of 5 minutes is, therefore, measured by the travel of switch S from position 2 to position 12. With brush 9 in position 12, a circuit is closed from battery through resistance 39, through lamp 19, and through the winding of relay 20 to ground. Lamp 19 lights and relay 20 operates to light the pilot lamp 21. The operator seeing these lamps lighted with the calling and called supervisory lamps extinguished, either makes out an overtime charge ticket or requests the deposit of an additional coin if the calling station is a coin-box station. The release key 22 is now operated to release the switch S, and any other switches which may be in position 12, so that the timing of an additional conversation period may proceed. The key 22 closes a circuit for operating relays 23, 24 and 25. These relays connect ground to the twelfth terminal of each switch at the operator's position, thereby operating the stepping magnets of all switches which are in this position. The circuit for operating magnet 7 may be traced from battery through its winding, brush 8 in position 12, over conductor 26, to ground at relay 25. When the key 22 is released relays 23, 24, and 25 release thus causing the release of magnet 7 thereby advancing the brushes of switch S to position 13. In positions 13 to 22 inclusive a circuit is closed from battery through the winding of magnet 7, through brush 8, and through the back contact of magnet 7 to ground, thereby causing the alternate operation and release of magnet 7 to advance the brushes of switch S around to normal position.

Assume that key 22 is operated and the switch restored to normal before the next operation of

relay 34 which occurs at the beginning of the secondary timing unit cycle upon operation of relays 157 and 158, as hereinbefore described. With relay 18 being held under control of relay 17, magnet 7 is operated and released to again advance switch S to position 2. The reoperation of relays 27, 28 and 29 a half a second later causes the advance of switch S from position 2. Since terminal 2 is reached 30 seconds after switch S entered position 12 on its first cycle, the second conversation period will also consist of 5 minutes, the switch being advanced from position 3 to position 12 one step every 30 seconds by the periodical operation of relays 27, 28 and 29.

When the called party replaces the receiver on the receiver hook, relays 16 and 17 release. If the switch S is in any of positions 2 to 11 inclusive at the time relay 17 releases, relay 18 holds in the circuit through brush 9 until the switch is advanced to position 12. But if the plug 13 is removed from jack 12 relay 18 releases immediately even though switch S is in one of positions 2 to 11 inclusive; in this case the switch is advanced to position 12 by the closure of a circuit from battery through magnet 7, brush 8 in any of positions 2 to 11 inclusive, upper back contact of relay 18, lower back contact of relay 17, and through the back contact of magnet 7 to ground. When the switch S reaches position 12 the circuit for magnet 7 may be traced from brush 8 in position 12, through the lower back contact of relay 17, and through the back contact of magnet 7, thereby causing the switch to advance to position 13. The advance from position 13 to normal is completed as hereinbefore described.

When the receiver is replaced upon the receiver hook at the calling station relay 6 releases and supervisory lamp 4 is again lighted until the operator removes the plug 3 from jack 2. The cord equipment is now normal, ready for use on another call.

The invention is not limited in its application to the specific arrangement herein disclosed but may be employed in any system in which a timing and impulse transmitting mechanism of similar characteristics is required.

What is claimed is:

1. In a telephone system, subscribers' lines, a link for establishing a connection between a calling line and a called line, a measuring device for measuring the duration of conversation, means for sending periodic timing impulses to operate said measuring device, means for sending starting impulses before and after each timing impulse, and means controlled by said starting impulses to render said measuring device effective to measure the time consumed in a conversation.

2. In a telephone system, subscribers' lines, means including a link for establishing a connection between a calling line and a called line, a device for measuring unit periods of conversation, means for delaying the initiation of the operation of said device to measure the first unit period of conversation, and means for eliminating any delay in initiating the operation of said device to measure each additional unit period of conversation.

3. In a telephone system, subscribers' lines, means including a link for establishing a connection between a calling line and a called line, a device for measuring unit periods of conversation, means for indicating the response of the called subscriber, means for delaying the in-

initiation of the operation of said device to measure the first unit period of conversation, means for indicating the completion of each unit period measured by said device, means for returning said device to normal position, and means for eliminating any delay in initiating the operation of said device to measure additional unit periods of conversation.

4. In a telephone system, subscribers' lines, means including links for establishing connections between calling and called lines, a device for each of said links for measuring unit periods of conversation, means for supplying timing impulses for operating said devices, means for supplying a starting impulse in advance of each timing impulse, means for supplying a starting impulse subsequent to each timing impulse, means associated with each link for controlling the operation of the associated measuring device in response to the said starting and timing impulses, and means common to said links for indicating the end of each unit period of conversation.

5. In a telephone system, subscribers' lines, means including links for establishing connections between calling and called lines, a device for each of said links for measuring unit periods of conversation, means for supplying timing impulses for operating said devices, means for supplying a starting impulse in advance of each timing impulse, means for supplying a starting impulse subsequent to each timing impulse, means associated with each link for controlling the operation of the associated measuring device in response to the said starting and timing impulses, means common to said links for indicating the end of each unit period of conversation, and means common to said links for rendering said devices effective to measure additional unit periods of conversation.

6. In a telephone system, subscribers' lines, means including a link for establishing a connection between a calling line and a called line, a device for measuring unit periods of conversation, a mechanism for supplying timing impulses to operate said device, means including a mechanism for supplying a starting impulse subsequent to each of said timing impulses for initiating the operation of said device to measure the first unit period of conversation, and means including a mechanism for supplying a starting impulse in advance of each of said timing impulses for initiating the operation of said device to measure an additional unit period for conversation.

7. In a telephone system, subscribers' lines, means including a link for establishing a connection between a calling line and a called line, a device for measuring unit periods of conversation, a mechanism for supplying timing impulses to operate said device, a mechanism for supplying a starting impulse subsequent to each of said timing impulses, control means actuated in consequence of the answer of the called subscriber, means rendered effective by the first timing impulse and the succeeding starting impulse for initiating the operation of said device to measure the first unit period of conversation, means for indicating the completion of said unit period, and means including a mechanism for supplying a starting impulse in advance of each of said timing impulses for initiating the operation of said device to measure an additional unit period of conversation.

8. In a telephone system, subscribers' lines, means including a link for establishing a connection between a calling line, and a called line,

a device for measuring unit periods of conversation, means for supplying timing impulses for operating said device, means for supplying a starting impulse in advance of each timing impulse, means for supplying a starting impulse subsequent to each timing impulse, control means actuated in consequence of the answer of the called subscriber, means actuated by the first timing impulse subsequent to the actuation of said control means for rendering the succeeding starting impulse effective to initiate the operation of said device, means for indicating the completion of each unit period of conversation, and means for rendering said device effective to measure an additional unit period of conversation, the operation of said device to measure additional periods being initiated by the starting impulse which precedes the next timing impulse.

9. In a telephone system, subscribers' lines, groups of links for establishing connections between calling and called lines, a device associated with each of said links for measuring unit periods of conversation, means for supplying timing impulses to operate said devices, means for supplying a starting impulse subsequent to each timing impulse, a supervisory relay associated with each of said links for operation upon the response of the called subscriber, means associated with each of said links actuated upon receipt of the first timing impulse subsequent to the operation of the associated supervisory relay for rendering the succeeding starting impulse effective to initiate the operation of the associated device for measuring the first unit period of conversation, means for continuing the operation of said devices under control of said timing impulses, means associated with each of said links for indicating the end of a unit period of conversation, means including a key common to said links for returning each of said devices to normal, and means including mechanism for supplying a starting impulse in advance of each of said timing impulses for initiating the operation of said devices for measuring additional unit periods of conversation.

10. In a telephone system, subscribers' lines, groups of links for establishing connections between calling and called lines, measuring devices one for each of said links for measuring the duration of conversation between a calling and a called line, mechanism for supplying timing impulses to operate said devices, mechanism for sending starting impulses before and after each timing impulse to initiate the operation of said devices to measure unit periods of conversation, and means common to each group of links for receiving said timing and starting impulses.

11. Impulse sending mechanism comprising a clock, means controlled by said clock for creating master impulses at a given frequency, a primary timing unit controlled by said master impulses for creating primary timing impulses at a different frequency, a secondary timing unit controlled by said primary timing impulses for creating secondary timing impulses at a third frequency and for creating other impulses one preceding and one succeeding each of said secondary timing impulses.

12. Impulse sending mechanism comprising a clock, means controlled by said clock for creating master impulses at a given frequency, a plurality of primary timing units controlled by said master impulses for creating primary timing impulses at a different frequency, a secondary timing unit controlled by said primary timing impulses for

creating secondary timing impulses at a third frequency and for creating other impulses one preceding and one succeeding each of said timing impulses by definite intervals, a key for transferring said master impulses and said secondary timing unit from one primary timing unit to the other, and means included in each of said primary timing units for preventing any decrease in the interval between the primary timing impulses received by said secondary timing unit on account of the transfer of said secondary timing unit from one primary timing unit to the other.

13. Impulse sending mechanism comprising a clock, means controlled by said clock for creating master impulses at a given frequency, a primary timing unit controlled by said master impulses for creating primary timing impulses at a different frequency, a plurality of secondary timing units controlled by said primary timing impulses for creating secondary timing impulses at a third frequency and for creating other impulses one preceding and one succeeding each of said secondary timing impulses, impulse receiving means one for each of said secondary timing units, a key associated with each of said secondary timing units for transferring the associated impulse receiving means to another one of said secondary timing units, and means included in each of said secondary timing units for preventing a decrease in the interval between the secondary timing impulses received by any one of said impulse receiving means on account of the transfer of said one of said impulse receiving means from one secondary timing unit to another.

14. The combination in a telephone system of a plurality of cord circuits for establishing conversational connections, timing devices each individual to one of said cord circuits, operating magnets for said timing devices, means responsive to the establishment of a connection over one of said cord circuits for energizing the magnet of the corresponding timing device, a signal, means for driving said timing device to a signaling position for indicating the completion of a unit period of conversation, means controlled by said timing device in said signaling position for actuating said signal, a key common to said timing devices, and a circuit controlled jointly by said key and by a timing device in said signaling position for restoring such device to its normal position.

15. In a telephone system, calling lines and called lines, cords for connecting said lines for conversation, timing devices one for each of said cords, means in each cord for placing the associated timing device into operation upon answer of the called subscriber, and a single key common to all of said cords for releasing the devices of cords which are awaiting disconnection at the time said key is operated.

16. In a telephone system, calling lines and called lines, cords for connecting said lines for conversation, timing devices one for each of said cords, means in each cord for placing the associated timing device into operation upon answer of the called subscriber, and a single key common

to all of said cords for releasing only the devices of cords which are awaiting disconnection at the time said key is operated.

17. In a telephone system, subscribers' lines, cords for use in establishing connections between any two of said lines, an individual device for each cord for measuring a predetermined interval of time during which a connection between two of said lines is maintained, a source of timing impulses for operating said devices, means in each cord responsive to a talking connection being established between two of said lines for operatively associating the device of said cord with said source, and means common to said devices for causing the restoration to normal of any device which has completed the measurement of said predetermined interval.

18. In a telephone system, subscribers' lines, cord circuits for use in establishing connections between any two of said lines, an individual device for each cord circuit for measuring a predetermined interval of time during which a talking connection is maintained between two of said lines, means in each of said circuits for initiating the operation of the associated time measuring device in response to the completion of the talking connection between two of said lines, means common to said devices for causing the restoration to normal of any device which has completed the measurement of said predetermined interval, and means individual to each cord circuit and operative in response to the opening of the talking connection through the cord circuit for causing the restoration of the associated individual time measuring device to normal.

19. In a telephone system, subscribers' lines, a plurality of cord circuits for use by an operator in establishing connections between any two of said lines, an individual timing device for each of said cord circuits for measuring a predetermined interval of time during which a connection is maintained, an individual signal for each of said cord circuits for indicating to the operator the completion of the measurement of said interval of time by the associated timing device, and a common means for restoring to normal any device which has completed the measurement of said interval of time.

20. In a telephone system, subscribers' lines, a plurality of links for use in establishing connections between any two of said lines, an individual device for each of said links for measuring a predetermined interval of time during which a connection between two of said lines is maintained through the link, an individual signal for each link energized upon completion of the measurement of said predetermined interval of time by the associated device, a signal common to said links energized upon completion of the measurement of said predetermined interval of time by the device of any one of said links, and means for resetting at one time all devices which have completed the measurement of said interval.

CLARENCE B. FOWLER.
JOHN W. GOODERHAM.