May 11, 1937. J. O'D. SHEPHERD 2,079,721

METERING SYSTEM

Filed July 23, 1932 3 Sheets-Sheet 1

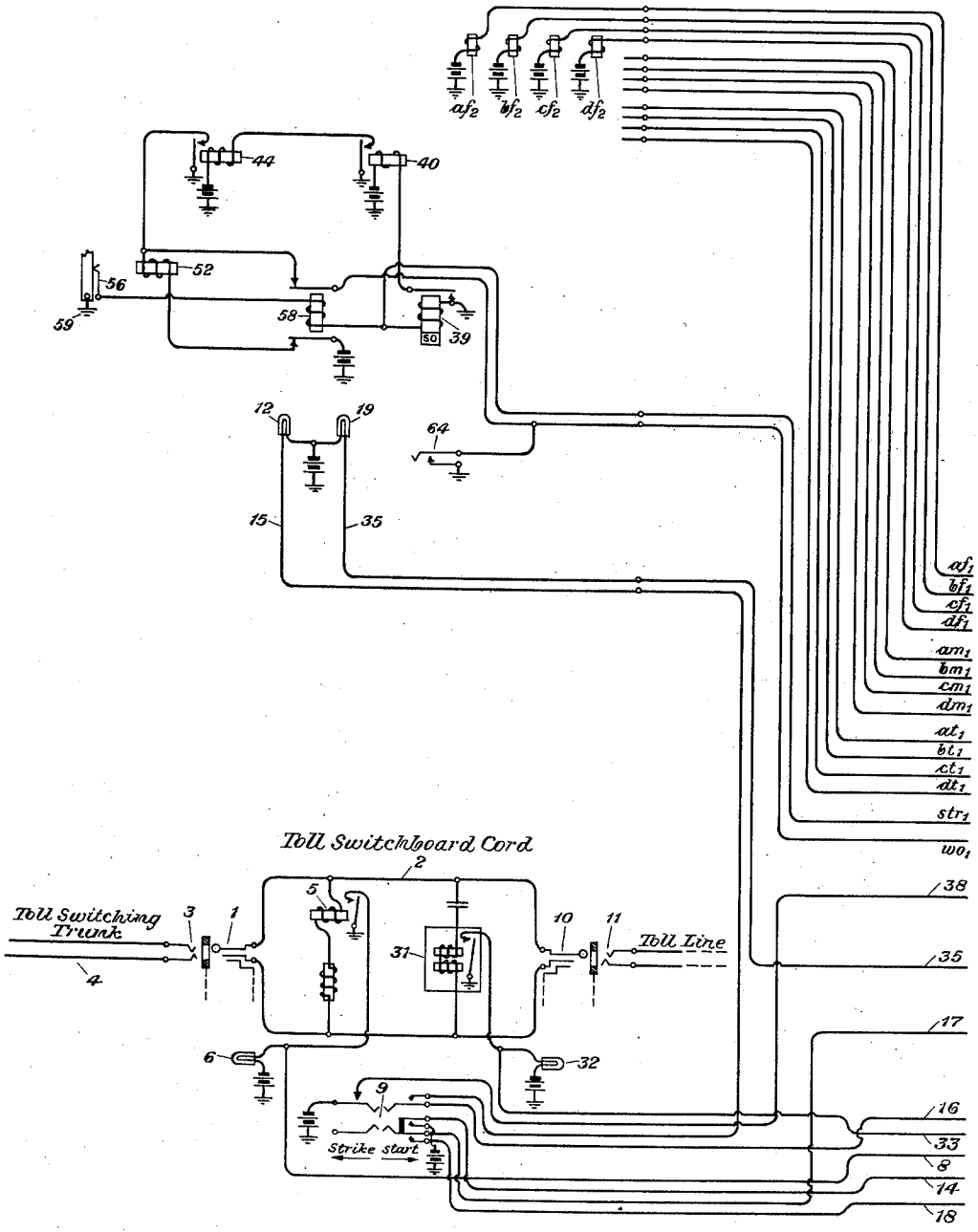


Fig. 1

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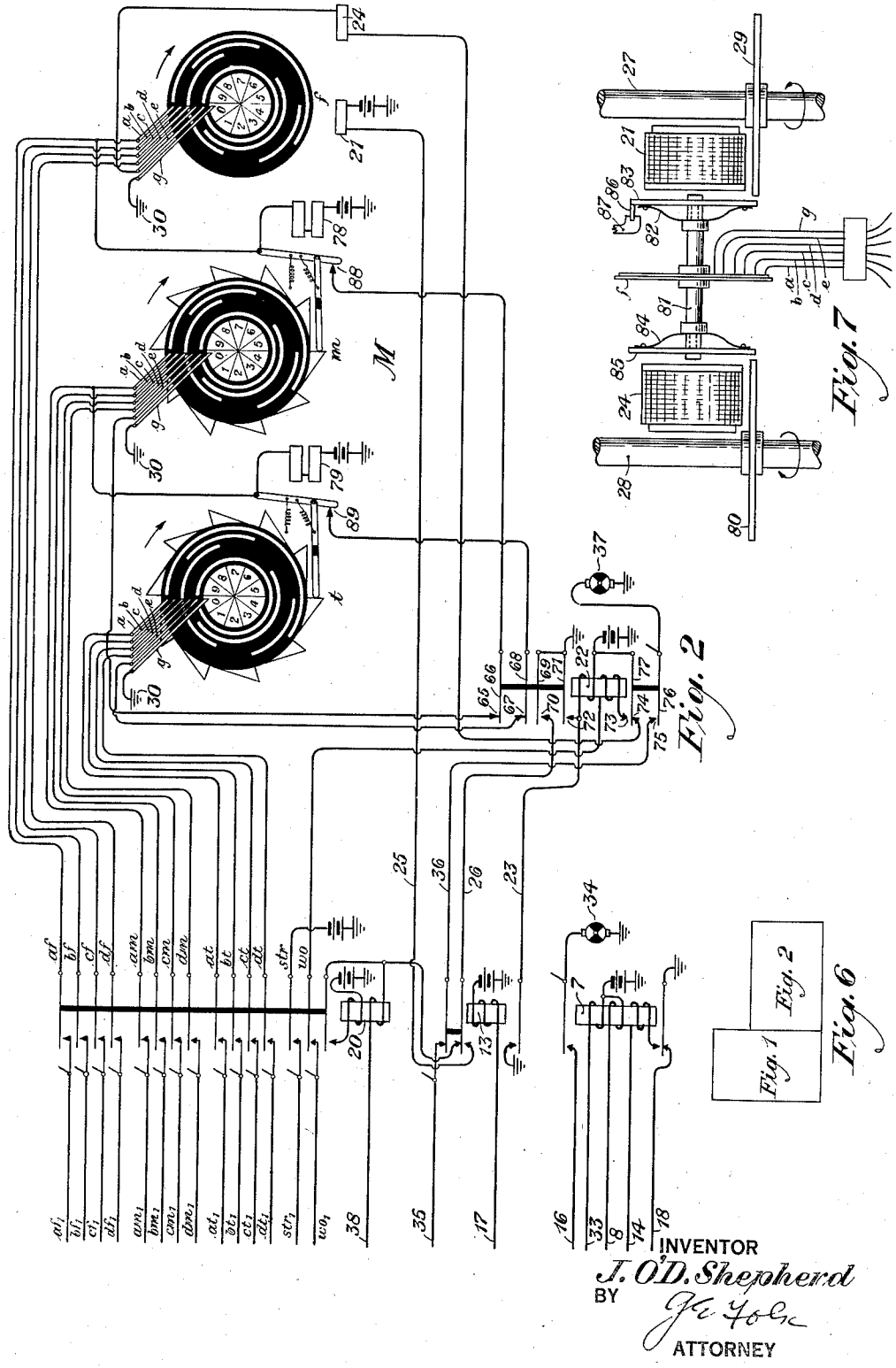


Fig. 7

Fig. 2

Fig. 1 Fig. 2

Fig. 6

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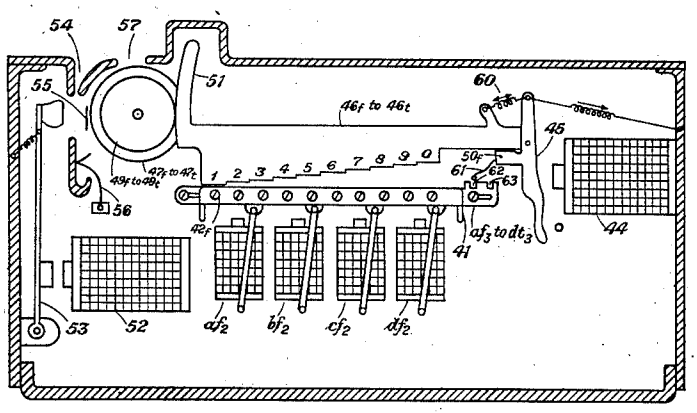


Fig. 3

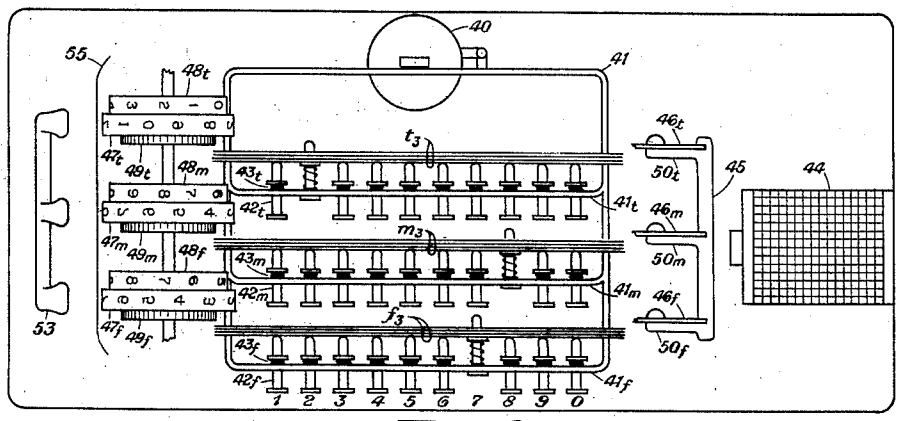


Fig. 4

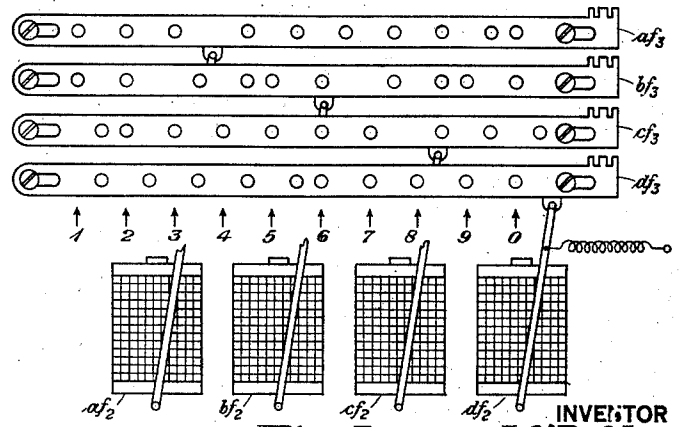


Fig. 5

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UNITED STATES PATENT OFFICE

2,079,721

METERING SYSTEM

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Application July 23, 1932, Serial No. 624,257

22 Claims. (Cl. 179—7.1)

This invention relates to measuring systems, and more particularly, to systems for measuring the time duration or the elapsed time of toll connections of a telephone system and for automatically printing said elapsed time.

Heretofore, what is generally known as calculagraphs were used for timing such connections. The calculagraph was primarily a master clock operated independently of the telephone circuits. At the beginning of a call the toll operator would insert a ticket in the clock and operate a lever. There would be printed on the ticket the dial of a clock with arrows indicating the time of day, a minute dial with an arrow indicating the minute and a five-minute dial with an arrow indicating the five-minute interval. At the termination of the call the operator would again insert the ticket in the clock and operate a lever. There would be printed on the dials other arrows from which the elapsed time and the charge could be computed.

The present invention provides an electrical timing system associated with the toll switchboard. This system includes a motor or clock driven elapsed time meter for each cord circuit, control circuits for controlling the starting, stopping and flushing of said meters, an electrically controlled printing mechanism for each switchboard position or for every two positions for printing the elapsed time measured by any of said meters, signaling apparatus for indicating the condition of said meters and printing mechanism, and an operator's key for each cord circuit for starting and stopping the corresponding meter and for transmitting the reading of the meter (the elapsed time) to the printing mechanism which automatically prints the elapsed time on a ticket inserted therein. As disclosed, the starting of the elapsed time meters, the printing of the elapsed time measured by the meters and the flushing of the meters are under the control of the operator, and the stopping of the meters is controlled by the operator or by the disconnect signal received by the operator at the termination of a call.

Figures 1 and 2 of the drawings when placed together in the manner indicated in Fig. 6, show schematically the electrical circuits of the system; Fig. 3 is a diagrammatic illustration of one side of the printing mechanism; Fig. 4 is a diagrammatic illustration of the top of the printing mechanism with the cover removed; Fig. 5 is a diagrammatic illustration of the selector bars and selector magnets of the printing mechanism; and Fig. 7 is a diagrammatic illustration of the driving means, and the start, stop and reset means associated with the fraction-minute wheel of one of the time meters.

The invention and the objects and features thereof, may be best understood by reference to the following detailed description of the operation of the system. Any necessary description of the apparatus will be set forth from time to time in connection with the description of the operation of the system.

When the toll switchboard operator ascertains from the calling party the details of the desired connection, she inserts answering plug 1 of a toll switchboard cord circuit 2 in jack 3 of a toll switching trunk 4. If the desired connection is of the type in which the calling party remains at his instrument and keeps his receiver off the hook, no current is impressed on the toll switching trunk and supervisory relay 5 remains unoperated. If the desired connection is of the "call-back" type, current is impressed on the toll switching trunk when the receiver of the calling party is replaced on its hook, and relay 5 operates and causes supervisory lamp 6 to be lighted. The operation of relay 5 also closes the circuit of the middle winding of stop relay 7 and causes the operation thereof. This circuit may be traced from the grounded battery at relay 7, through the middle winding of said relay and lead 8 to the contact and grounded armature of relay 5. The operation of relay 7 at this time has no effect on the system because the operator's control key 9 is in its normal position. The operator now inserts plug 10 in jack 11 of the toll line leading to a distant central office with which the local circuit of the called party is associated, signals said distant central office and communicates the necessary information concerning the call to the distant central office operator, who in turn completes the connection to the called party.

When the called party answers, the operator at the central office associated with the line of the calling party notifies said calling party that the connection is ready. Of course, if the connection is of the "call-back" type, said operator rings the calling party and upon his response notifies him that the connection is ready. The answer of the calling party, in response to the ringing signal, removes battery from trunk 4 and causes the release of relay 5. Lamp 6 is extinguished, and relay 7 is released. The operator then operates key 9 to the right to its start position. The operation of key 9 to this position prepares a locking circuit for relay 7, prepares a flashing circuit for lamp 12 which is associated with the

printing mechanism, and closes the circuit of start relay 13. Said locking circuit for relay 7 may be traced from the grounded battery at key 9, through the middle right contact and spring of key 9, lead 14, lower winding of relay 7, to the lower front contact of relay 7. Said flashing circuit for lamp 12 may be traced from grounded battery at said lamp, through lead 15, the upper right contact and spring of key 9 and lead 16 to the upper front contact of relay 7. The circuit of start relay 13 may be traced from grounded battery at said relay, through the winding of said relay, lead 17, the lower right spring and contact of key 9, lead 18, and the lower back contact of relay 7 to the grounded lower armature of relay 7. The closure of the latter circuit causes the operation of start relay 13. In operating, relay 13 opens at a second point, i. e. its upper back contact, the normally open flashing circuit of lamp 19. At its lower back contact said relay opens at a second point the normally open operating and locking circuits of cut-through relay 20. At its upper front contact said relay prepares an operating circuit for start magnet 21. At its lower front contact said relay closes the operating circuit of wipe-out relay 22. The circuit of the wipe-out relay may be traced from the grounded battery at said relay, through its upper winding, lead 23, and the lower armature of relay 13 to the grounded lower front contact of relay 13. Relay 22 in operating, closes a locking circuit for itself through its upper winding, contact 72, armature 71, and the ground associated with said armature. At contact 73 said relay prepares a release circuit for itself which may be traced from the grounded battery at said relay, through armature 77, contact 73, its lower winding, which is a differential winding, lead *wo* to the armature of relay 20. At contacts 74, 65 and 67 said relay opens at a second point the respective circuits of release magnet 24 and stepping magnets 78 and 79. The functions and circuits of these magnets will be explained below. At contact 75 relay 22 prepares a flashing circuit for lamp 19. At contact 70 said relay closes the operating circuit of rotary magnet 21, the circuit of which was previously prepared by the operation of relay 13. The operating circuit of magnet 21 may be traced from the grounded battery of said magnet, through the winding of said magnet, lead 25, the upper front contact of relay 13, the upper middle armature of relay 13, lead 26, contact 70 of relay 22, to grounded armature 69 of relay 22. The operation of magnet 21 sets the elapsed time meter M into operation.

The elapsed time meter M, its driving means and the circuits associated therewith, are shown schematically in Figs. 2 and 7. As shown, the meter consists of a driving shaft 27, a restoring shaft 28, a fraction-minute dial wheel *f*, a minute dial wheel *m*, a ten-minute dial wheel *t*, stepping magnets 78 and 79, and a plurality of brushes. Fraction-minute wheel *f* is adapted to be rotated during the timing of the call by driving shaft 27. Driving shaft 27 is rotated continuously at a constant speed by a constant speed synchronous motor, for example. Minute wheel *m* is adapted to be rotated periodically through a predetermined arc, for example $\frac{1}{10}$ of a revolution, by stepping magnet 78 which is operated and released once during each revolution of the fraction-minute wheel. Ten-minute wheel *t* is adapted to be rotated periodically through a predetermined arc, for example $\frac{1}{10}$ of a revolution, by stepping magnet 79 which is operated and released once during each revolution of the minute wheel. The fraction-minute wheel is restored to its normal zero position by restoring shaft 28, which is adapted to be rotated continuously at a greater speed than shaft 27. During their restoration the fraction-minute wheel, the minute wheel and the ten-minute wheel rotate in the same direction as they do during the timing of the call. When the fraction-minute wheel, during the restoring operation, reaches its normal zero position, stepping magnet 78 becomes operative to restore the minute wheel from any off-normal position to its normal zero position, and when it reaches its normal zero position, stepping magnet 79 becomes operative to restore the ten-minute wheel from any off-normal position to its normal zero position. Driving shaft 27 and restoring shaft 28 may be rotated by different motors or by the same motor through suitable gearing apparatus. A driving disc 29 is mounted on driving shaft 27 and a restoring disc 80 is mounted on restoring shaft 28. Fraction-minute wheel *f* is mounted on a shaft 81, the axis of which is at right angles to the axes of shafts 27 and 28. On one end of shaft 81 is mounted by means of spring 82 a disc 83, and on the other end is mounted by means of spring 84 a disc 85. As shown in Fig. 7, the rotary magnet 21 is positioned between the face of disc 83 and shaft 27, release magnet 24 is positioned between the face of disc 85 and shaft 28, and the faces of discs 83 and 85 are positioned adjacent the periphery of discs 29 and 80, respectively. When rotary magnet 21 is operated, disc 83 is adapted to be moved into engagement with disc 29 and be rotated thereby at a constant predetermined speed. When release magnet 24 is operated, disc 85 is adapted to be moved into engagement with disc 80 and be rotated thereby at a greater speed. As shown in Fig. 2, each of the wheels is divided into ten sections numbered from zero to 9. A group of five brushes *a* to *e*, inclusive, is provided to press against each wheel at points in a straight line with respect to the radius of each wheel. On each section of each wheel is embedded insulating material to form a different pattern according to a predetermined code. The pattern of the corresponding section of each of the wheels is the same. The uninsulated parts of each section of each wheel form a conducting path from brushes *a* to *e*, inclusive, to brush *g* which is grounded at 30. It can be seen therefore, that as the wheels rotate, certain brushes associated with each wheel will come in contact with the uninsulated portions of the sections and will be connected to ground according to a predetermined code. For example, when the wheels are in their normal or zero position brush *c* of each wheel is connected to ground. Now suppose the connection described above should last 28.7 minutes. Fraction-minute wheel *f* would be in such a position that the brushes would be in contact with section numbered 7 and brushes *a* and *b* would be connected to ground. Minute wheel *m* would be in such a position that the brushes associated therewith would be in contact with section numbered 8 and brushes *a*, *b* and *c* would be connected to ground. Ten-minute wheel *t* would be in such a position that the brushes associated therewith would be in contact with section numbered 2 and brush *d* would be connected to ground. It will be noted from an inspection of the drawing that that part of each wheel which is under brush *e* is not insulated in any of the sections except that numbered zero

of which only one spot is insulated and that the brushes *e* will always be connected to ground except at the moment when the wheels are in their normal positions. This insures the operation of release magnet **24**, stepping magnet **78** or stepping magnet **79**, as the case may be, when wipe-out relay **22** is released, no matter in what position, other than normal, any of the wheels are. The provision of an electrical carry-over arrangement in contradistinction to an ordinary mechanical carry-over arrangement is preferable in that it tends to insure more accurate registration. However, it is to the understood that the invention in its broader aspects is not limited to an electrical carry-over arrangement nor to the particular carry-over arrangement disclosed.

Returning now to the operation of the system, it will be recalled that when the connection was ready, the operator operated key **9** to its start position. This caused the operation of relay **13** which in turn caused the operation of relay **22**. The operation of relays **13** and **22** caused the operation of rotary magnet **21**. The operation of magnet **21** attracts disc **83** and causes it to move into engagement with rotating disc **29** and be rotated thereby at a constant predetermined speed. The rotation of disc **83** causes the rotation of fraction-minute wheel *f* at a constant predetermined speed. When the fraction-minute wheel has rotated 24 seconds or through $\frac{4}{10}$ of a revolution it is in such position that its brushes are in contact with the section numbered **4** and brush *a* is connected to ground. This completes the circuit for and causes the operation of stepping magnet **78**. This circuit may be traced from grounded battery through the winding of said magnet, brush *a* and brush *g*, to ground **30**. The operation of magnet **78** causes the pawl associated with its armature to engage the next tooth of minute wheel *m*. Magnet **78** remains operated as the fraction-minute wheel rotates for the next 36 seconds or through the next $\frac{6}{10}$ of its revolution. As the fraction-minute wheel rotates from a position such that its brushes are in contact with the section numbered **9** to a position such that its brushes are again in contact with the section numbered **0**, the connection between brush *a* and grounded brush *g* is broken and magnet **78** releases. The release of magnet **78** steps minute wheel *m* $\frac{1}{10}$ of a revolution. When the fraction-minute wheel has rotated 4 revolutions minute wheel *m* is in such position that its brushes are in contact with the section numbered **4**, and a circuit is completed for the operation of stepping magnet **79**. This circuit may be traced from grounded battery through the winding of said magnet and brushes *a* and *g* of minute wheel *m* to ground **30**. The operation of magnet **79** causes the pawl associated with its armature to engage the next tooth of ten-minute wheel *t*. Magnet **79** remains operated until minute wheel *m* rotates from a position such that its brushes are in contact with the section numbered **9** to a position such that the brushes are again in contact with the section numbered **0**, at which time the connection between brush *a* and grounded brush *g* of minute wheel *m* is broken and magnet **79** is released. The release of magnet **79** steps ten-minute wheel *t* $\frac{1}{10}$ of a revolution. The measuring wheels of the meter M continue to rotate as described above, as long as the connection remains established.

At the termination of the call the restoration of the receiver to the hook by the calling party causes the operation of relay **5**, or, the signaling of the local operator by the distant operator causes the operation of relay **31**, whichever occurs first. As described above, the operation of relay **5** causes lamp **6** to be lighted and causes the operation of stop relay **7** through its middle winding. Relay **31** may be an alternating current relay or a chain of relays adapted to be operated by alternating current. If the signal from the distant operator should be received before the calling party restores his receiver to its hook, relay **31** will be operated which will cause supervisory lamp **32** to be lighted and cause stop relay **7** to be operated through its upper winding. The latter circuit may be traced from the grounded battery at relay **7**, through its upper winding, lead **33**, to the contact and grounded armature of relay **31**. The operation of stop relay **7** opens at its lower back contact the circuit of start relay **13**, which was traced above. At its lower front contact relay **7** closes a locking circuit for itself through the circuit which was prepared by the operation of key **9** to its start position and which was described above. At its upper front contact relay **7** closes the flashing circuit of lamp **12**. The flashing of this lamp is caused by the operation of interrupter **34** which intermittently removes ground from the circuit. The release of relay **13** opens at its upper front contact the circuit of rotary magnet **21**, the release of which permits disc **83** to return under the influence of spring **82** to its normal disengaged position with respect to disc **29**. This, of course, stops the operation of the meter. At its lower front contact relay **13** opens the operating winding of relay **22**, but said relay remains operated through its locking circuit. At its lower back contact relay **13** prepares an operating and locking circuit for cut-through relay **20**. At its upper back contact relay **13** closes the flashing circuit of lamp **19**. The latter circuit may be traced from grounded battery at lamp **19**, through said lamp, lead **35**, the upper back contact of relay **13**, the uppermost armature of said relay, lead **36**, contact **75** of relay **22**, armature **76** of said relay, to interrupter **37** and ground. It will be noted that the circuit of lamp **12** is under the control of key **9** and stop relay **7**, whereas the circuit of lamp **19** is under the control of start relay **13** and wipe-out relay **22**. As a result lamp **12** starts flashing as soon as stop relay **7** is operated due to the restoration of the receiver at the calling subscriber's station or to the reception of the disconnect signal from the distant central office. This indicates that the call has been terminated. A moment later lamp **19** starts flashing due to the release of start relay **13** and of rotary magnet **21**. This indicates that the timing apparatus has ceased to rotate, that the talking connections may be taken down, that the operator's key **9** may be restored to normal or operated to strike position, and that the elapsed time now recorded on the meter may be transmitted to the printing apparatus which is adapted to print said elapsed time on a ticket inserted therein.

The operator now takes down the connection by removing plugs **1** and **10** from jacks **3** and **11**, respectively, which causes supervisory lamps **6** and/or **32** to be extinguished and the circuits of the upper and middle windings of stop relay **7** to be opened. Then the operator restores key **9** to its normal position. The restoration of key **9** to its normal position opens at its upper right contact and spring the flashing circuit of lamp **12**, opens at the middle contact and spring the

locking circuit of stop relay 7, and opens at a second point the operating circuit of start relay 13. Lamp 19 continues to flash, which indicates that there is an elapsed time reading on one of the meters awaiting transmission to the printing apparatus. The release of stop relay 7 opens at a second point its locking circuit and the flashing circuit of lamp 12 and also prepares a circuit for the reoperation of start relay 13 when the cord circuit is used for establishing another talking connection. It is apparent from the drawings that, as described above, the cord circuit may be taken down before the restoration of key 9 to its normal position, or that it may remain up until after the key has been restored to normal, or even until after the key has been operated to the strike position and the reading printed on a ticket inserted in the printing apparatus.

The operator next inserts the ticket in slot 54 of the printing mechanism (Fig. 3) and operates key 9 (Fig. 1) to its strike position which causes the operation of cut-through relay 20. This circuit may be traced from grounded battery at the left of key 9, through the left upper spring and contact of key 9, lead 38, lower winding of relay 20, lower back contact of relay 13, middle armature of relay 13, lead 26, contact 70 of relay 22, armature 69 of relay 22, to ground. Upon operating, relay 20 immediately closes a locking circuit for itself which may be traced from grounded battery at said relay, through the upper winding of said relay, the lowermost front contact and the lowermost armature of said relay, the lower front contact of relay 13, and through lead 26 to ground at relay 22. Cut-through relay 20 is of the gang type and is adapted to connect through its contacts and armatures leads *af* to *dt*, inclusive, with leads af_1 to dt_1, respectively, and also to connect control leads *str* and *wo* with leads str_1 and wo_1, respectively. In other words, the operation of relay 20 connects ground to certain of the conductors af_1 to dt_1, inclusive, depending upon the positions of wheels *f*, *m* and *t*, which determine which of brushes *a* to *d* are connected to ground 30. In the illustration given above the elapsed time recorded by meter M was supposed to be 28.7 minutes. In this case leads af_1, bf_1, am_1, bm_1, cm_1 and dt_1 would be connected to ground.

The essential features of the printing mechanism are shown schematically in Figs. 3, 4 and 5, and the electrical circuits therefor are shown schematically in the upper part of Fig. 1. The printing mechanism includes three groups of four selector magnets, three groups of four selector bars and three groups of ten spring pins. One group of selector magnets, selector bars and spring pins is provided for each dial wheel of the elapsed time meter—namely, the fraction-minute wheel, the minute wheel, and the ten-minute wheel. The four selector magnets and the four selector bars of each group correspond to brushes *a* to *d*, respectively, which are associated with each of the dial wheels. The ten spring pins of each group correspond to numerals zero to 9. Each selector bar is connected to the armature of a selector magnet and is adapted to be shifted to the left, for example, when the corresponding selector magnet is energized. The arrangement of the selector bars and magnets is shown schematically in Figs. 3 and 5, only those corresponding to the fraction-minute wheel being shown. The selector magnets are designated by reference characters af_2 to df_2, inclusive, and the selector bars are designated by reference characters af_3 to df_3 inclusive. As shown in Fig. 5, each selector bar has a plurality of holes therein, the relative position of each hole being in accordance with a predetermined code which corresponds to the code in the meter. Each group of spring pins 42_f, 42_m and 42_t (Fig. 4) is carried by and inserted through a light frame 41_f, 41_m and 41_t. Each frame forms a part of armature 41 of positioning magnet 40. Associated with each pin and located between the frame and a stop member on each pin is a spring 43_f, 43_m and 43_t, the function of which will be explained later. The printing mechanism also includes a register magnet 44 having a pivoted armature 45, three register bars 46_f, 46_m and 46_t, and three type wheels comprising the printing wheels 47_f, 47_m and 47_t, visual wheels 48_f, 48_m and 48_t, and pinion wheels 49_f, 49_m and 49_t. The arrangement of the register magnet, the register bars and the type wheels, is shown schematically in Figs. 3 and 4. Each register bar, one for each digit, is pivoted at one end and is supported thereat, when the register magnet is unoperated, by supporting bars 50_f, 50_m and 50_t, which form parts of armature 45. The other end of each register bar terminates in a rack 51 which engages pinion wheels 49_f, 49_m and 49_t, respectively. Each register bar has a series of stops on its under side, these stops being carefully designed as to relative height in view of the turning radius of the bars and pinion wheel. There is a stop corresponding to each of the ten spring pins. For a given number to be printed the selector magnets and the positioning magnet operate to cause the proper pin to be projected through the selector bars. When the register magnet operates and causes the register bars to be forced down, said bars encounter the projecting pins and are stopped. The movement of the register bars positions, by means of the racks and pinion wheels, the type wheels for the numerals to be printed. After the type wheels have been positioned a strike magnet 52 is energized causing the hammers associated with its armature 53 to strike a ticket which has been inserted in the slot indicated at 54 in Fig. 3. The impact forces the ticket against an inked ribbon 55 and the numerals on the printing wheels positioned in front of it, and causes the numerals to be printed on said ticket. The insertion of the ticket in the slot breaks a circuit between spring 56 and the grounded back of the slot. The function of this feature will be described later. The numerals on the printing wheels and on the visual wheels are so positioned with respect to one another that for each given type number positioned in front of the hammers, the corresponding numeral on the visual wheel is disclosed to the operator through a window in the top of the printing mechanism, said window being indicated at 57 in Fig. 3.

The electrical and mechanical operation of the printing mechanism will now be described with reference to the illustration given above in which 28.7 minutes was assumed to be the reading recorded on the elapsed time meter M. It will be recalled that the operator had operated key 9 to the strike position which in turn had caused the operation of cut-through relay 20, and that the operation of relay 20 had connected ground 30 to leads af_1, bf_1, am_1, bm_1, cm_1 and dt_1 and had connected grounded battery to leads str_1 and wo_1. The connection of ground to lead af_1 completes the operating circuit of selector magnet af_2. The operation of selector magnet af_2 by means of its armature slides selector bar af_3 to the left. Likewise, selector magnet bf_2 will be

operated over grounded lead bf_1 and will slide selector bar bf_3 to the left. An inspection of Fig. 5 will indicate that with these bars in their operated positions and the other bars in their normal positions, the holes in all the selector bars will be in alignment opposite the arrow numbered 7 which corresponds to the position of spring pin numbered 7, and that no other holes will be in alignment opposite any of the arrows. The connection of ground to leads am_1, bm_1 and cm_1 operates selector magnets am_2, bm_2 and cm_2. The m_2 magnets and the t_2 magnets are not shown in the drawings. However, it is understood that these magnets are located behind the f_2 magnets and occupy the same relative positions as said f_2 magnets. The same is true of the m_3 and t_3 selector bars. Consequently, an inspection of Fig. 5 will indicate that when selector bars am_3, bm_3 and cm_3 have been shifted to the left, the other remaining in its normal position, the holes of all the m_3 selector bars will be in alignment opposite the arrow or spring pin numbered 8 and that no other holes will be in alignment opposite any of the other arrows or spring pins. The connection of ground to lead dt_1 operates selector magnet dt_2, the operation of which in turn causes selector bar dt_3 to be shifted to the left. An inspection of Fig. 5 will indicate that when bar dt_3 has been shifted to the left, the others remaining in their normal positions, the holes in all the t_3 selector bars will be in alignment opposite the arrow or pin numbered 2 and that no other holes will be in alignment opposite any of the other arrows or pins. The connection of grounded battery to lead str_1 energizes relay 39 (Fig. 1). The circuit of relay 39 may be traced from grounded battery connected to lead *str* (Fig. 2), through lead *str*, the armature and contact of relay 20, lead str_1 and the winding of relay 39 to ground at said relay. The winding of relay 58 is connected in parallel with the winding of relay 39. However, relay 58 does not operate due to the fact that the operator inserted a ticket in slot 54 before operating key 9 to its strike position, said insertion breaking the connection between spring 56 (Figs. 1 and 3) and the back of the slot which is grounded at 59 (Fig. 1). Relay 39 is of the slow operating type and does not operate until after the selector magnets have been operated and the selector bars shifted to their left operated position. After the selector bars have been shifted to the left, relay 39 operates and closes the operating circuit of positioning magnet 40 (Figs. 1 and 4). This circuit may be traced from ground at relay 39 (Fig. 1), through the contact and armature of relay 39 and the winding of positioning magnet 40 to grounded battery.

Magnet 40 in operating attracts its armature 41 (Fig. 4) to the position shown. The movement of armature 41 to the position shown causes frames 41_f, 41_m and 41_t to press against all of the springs 43_f, 43_m and 43_t, and all of the pins 42_f, 42_m and 42_t of each group try to pass through the holes of the selector bars. However, it will be remembered that in the example given only the holes opposite the *f* spring pin numbered 7, the holes opposite the *m* spring pin numbered 8 and the holes opposite the *t* spring pin numbered 2 are in alignment. As a result only these three pins will be able to pass through the selector bars. The springs 43_f, 43_m and 43_t associated with the other pins are compressed by the movement of the frames and thus cause said other pins to press against said selector bars and at the same time permit the movement of the frames. The springs associated with the pins that pass through the bars are not compressed by the movement of the frames, but said springs transmit to the pins the force exerted by the movement of the frames in order to cause said pins to pass through the aligned holes in the selector bars. Fig. 4 shows the position of the pins in the example given, after the operation of the positioning magnet. Magnet 40 in addition to positioning the pins also closes the operating circuit of register magnet 44 (Figs. 1, 3 and 4). This circuit may be traced from the grounded armature of magnet 40 (Fig. 1), through the contact of said magnet and the winding of register magnet 44 to grounded battery.

Magnet 44 in operating, attracts its armature 45. The movement of armature 45 lowers the supporting members 50_f, 50_m and 50_t and by means of springs 60 forces down register bars 46_f, 46_m and 46_t until they strike the pins protruding through the selector bars. The lowering of supporting bars 50_f, 50_m and 50_t also moves springs 61 into slots 62 or 63, depending upon whether the corresponding selector bar has been shifted to the left or not. The movement of these springs into the slots locks the selector bars and prevents their derangement during the printing operation. As the register bars move downward until they strike the protruding pins, racks 51 rotate pinion wheels 49_f, 49_m and 49_t through an arc determined by the arc through which the corresponding register bar moves. In the example given the printing wheels 47_f, 47_m and 47_t would be rotated to positions in which the numeral 7 of the *f* wheel, the numeral 8 of the *m* wheel, and the numeral 2 of the *t* wheel would be opposite the respective hammers. With the printing wheels in this position the reading 28.7 on the visual wheels would also be visible through the aperture 57 as described above. In addition to positioning the type wheels the operation of register magnet 44 also closes the operating circuit of strike magnet 52 (Figs. 1 and 3). This circuit may be traced from the grounded armature and contact of magnet 44 (Fig. 1), through the winding of magnet 52 and the lower back contact and armature of relay 58, to grounded battery. Magnet 52 operates and causes the hammers associated with its armature 53 to strike the ticket and force it against ribbon 55 and the numerals on the printing wheel. This causes the reading to be printed on the ticket, said reading being 28.7 in the example given. This completes the printing operation.

In addition to causing the operation of strike magnet 52, the operation of register magnet 44 closes the circuit of the lower winding of wipe-out relay 22. This circuit may be traced from the grounded armature and contact of magnet 44 (Figs. 1 and 2), the upper back contact and armature of relay 58, lead wo_1, the contact and armature of relay 20, lead *wo*, the lower winding of relay 22, contact 73 and armature 77 of relay 22, to grounded battery at said relay. Relay 22, being differentially wound, releases. The release of relay 22 opens at contact 72 its own locking circuit, opens at contact 70 the operating and the locking circuit of relay 20, opens at contact 75 the flashing circuit of lamp 19, closes at contact 74 the operating circuit of release magnet 24 in case the fraction-minute wheel *a* of the elapsed time meter is in an off-normal position, closes at contact 65 the operating circuit of stepping magnet 78 in case the minute wheel *m* is in an off-normal position, and closes at contact 67 the operating circuit of stepping magnet 79 in case the ten-minute wheel *t* is is an off-normal position. The

release of relay 20 removes grounded battery from lead str_1 which causes the release of relay 39. The release of relay 39 causes the release of the magnets of the printing mechanism which restores all said printing mechanism to normal except the selector bars. The release of relay 20 also removes ground from leads af_1 to dt_1, inclusive, which releases any of selector magnets af_2 to dt_2, inclusive, which may be operated. The release of the latter magnets restores the selector bars to normal. The operation of release magnet 21 and/or stepping magnet 78 and/or stepping magnet 79 restores the wheels of the elapsed time meter to their normal zero position. The extinguishment of lamp 19 indicates to the operator that the printing mechanism has been restored to normal and that said apparatus may be used again for another connection. After the extinguishment of lamp 19 the operator then, of course, operates key 9 from its strike position to its normal position.

The restoring operation of the meter will be described with reference to the example given above. It will be recalled that under said example the section numbered 7 of the fraction-minute wheel, the section numbered 8 of the minute wheel, and the section numbered 2 of the ten-minute wheel were under the respective groups of brushes when key 9 was operated to stop the timing of the call. With the fraction-minute wheel in this position brushes *a* and *e* thereof will be connected to ground 30 through brush *g* thereof and, as a result, the circuit of release magnet 24 will be prepared, the circuit of stepping magnet 78 will be closed, and stepping magnet 78 will be operated. With the minute wheel in this position brushes *a* and *e* thereof will be connected to ground 30 through brush *g* thereof and, as a result, the circuit of stepping magnet 79 will be closed, magnet 79 will be operated, and the stepping circuit of magnet 78 will be prepared. With the ten-minute wheel in this position brush *e* thereof will be connected to ground through brush *g* thereof and the stepping circuit of magnet 79 will be prepared. Now, when relay 22 is released as described above, its release will have no immediate effect on stepping magnets 78 and 79 and as a result the minute wheel *m* and the ten-minute wheel *t* will remain stationary for the time being, but the release of relay 22 will cause the immediate operation of magnet 24. The operation of magnet 24 attracts disc 85 and causes it to move into engagement with disc 80 and be rotated thereby at a comparatively high speed. This causes the fraction-minute wheel to be rotated until its section numbered 9 passes out from under the brushes associated with said wheel, at which time ground is removed from release magnet 24 and stepping magnet 78. The release of magnet 24 permits disc 85 to return under the influence of spring 84 to its normal disengaged position with respect to disc 80 and the rotation of fraction-minute wheel *f* ceases, it now being in its normal zero position. The release of stepping magnet 78 steps minute wheel *m* $\frac{1}{10}$ of a revolution by means of the pawl associated with its armature. When the armature of magnet 78 reaches its full released position, it closes at contact 88 a stepping circuit for said magnet. This circuit may be traced from grounded battery through the winding of said magnet, the armature of said magnet, contact 88, armature 66 and contact 65 of relay 22 and brushes *e* and *g* of the minute wheel, which is in an off-normal position, to ground 30. Magnet 78 operates and releases repeatedly, and, as a result, steps minute wheel *m* around until section numbered 9 thereof passes out from under the brushes associated with said wheel, at which time ground is removed from brushes *a* and *e* thereof. The removal of ground from brush *e* prevents the further operation of stepping magnet 78 and hence, minute wheel *m* stops rotating and remains in its normal zero position. The removal of ground from brush *a* releases stepping magnet 79. The release of this magnet steps ten-minute wheel *t* $\frac{1}{10}$ of a revolution. The full release of the armature of magnet 79 closes a stepping circuit for said magnet. This circuit may be traced from grounded battery through the winding of said magnet, the armature of said magnet, contact 89, armature 68 and contact 67 of relay 22, and brushes *e* and *g* of ten-minute wheel *t* to ground 30. Magnet 79 operates and then releases repeatedly, and, as a result, steps ten-minute wheel *t* around until section numbered 9 thereof passes out from under the brushes associated with said wheel, at which time ground is removed from brush *e*. The removal of ground from brush *e* prevents the further operation of stepping magnet 79 and hence, ten-minute wheel *t* stops rotating and remains in its normal zero position. All three wheels have now been restored to their normal zero positions. Of course, it is understood that the stepping magnets operate very rapidly and that the entire restoring operation of the three wheels takes place in a very short time.

The restoring operation of the wheels from any off-normal position is identical with that described above, except where either or both of wheels *f* and *m* are in such position, when relay 22 is released, that the brushes thereof are in contact with any of the sections numbered 0 to 3, inclusive. If wheel *f* is in such a position, stepping magnet 78 will begin to operate as soon as relay 22 releases and will rotate the minute wheel until the brushes of the fraction-minute wheel come in contact with section numbered 4, whereupon said stepping magnet will operate and remain operated until the fraction-minute wheel is restored to its normal zero position. If minute wheel *m* is in such a position, stepping magnet 79 will begin to operate as soon as relay 22 releases and will continue to operate until the brushes of minute wheel *m* come in contact with section numbered 4, whereupon said stepping magnet will operate and remain operated until the minute wheel is restored to its normal zero position. From this point on the restoring operation is the same as that described above.

By referring to Fig. 7, it will be seen that a stud 86 is fastened to disc 83. This stud is adapted to come in contact with stop pawl 87 when the fraction-minute wheel reaches its normal zero position during the restoring operation. It will be apparent from an inspection of Fig. 7 that stud 86 will not engage pawl 87 during the timing of the call because disc 83 is attracted and moved to the right by magnet 21 when it is operated, but that said stud will engage said pawl during the restoring operation because at this time magnet 21 is unoperated and disc 83 is in its normal position. This additional stepping means is provided to insure that the fraction-minute wheel stops in its normal zero position without any overthrow, which, if such means were not provided, might occur during the restoring operation due to the comparatively high

speed at which the fraction-minute wheel is restored.

As shown, the system is so arranged that the operator at any time during the connection may take a reading of the elapsed time without printing said elapsed time, and without restoring the elapsed time meter to normal. To do this the operator merely operates key 9 to the strike position, notes the reading indicated on the visual wheel of the printing mechanism, and then restores key 9 to the starting position. As the key passes through its normal position in its movement from its start to its strike position, start relay 13 is released. The release of relay 13 releases rotary magnet 21 which stops the rotation of the meter, prepares an operating and locking circuit for cut-through relay 20, and closes the flashing circuit of lamp 19. The further movement of key 9 to its strike position causes the operation of cut-through relay 20. The operation of relay 20 in the same manner as before, closes a locking circuit for itself, prepares a circuit for the release of relay 22, causes the operation of certain selector magnets af_2 to dt_2 and causes the operation of relay 39, the latter in turn causing the operation of positioning magnet 40 and register magnet 44. As described above, the operation of these relays and magnets causes the type wheels of the printing mechanism to be rotated to such a position that certain numerals on the visual wheels corresponding to the elapsed time measured by the meter, are visible through the aperture indicated at 57, and the numerals on the printing wheels are positioned in front of the strike hammers. However, since no ticket is inserted in the slot indicated at 54, the circuit between spring 56 and the grounded back of the slot will remain closed. Hence, the operation of relay 20 causes the operation of ticket test relay 58. This circuit may be traced from the grounded back of the slot indicated at 59, through spring 56, the winding of relay 58, lead str_1, the contact and armature of relay 20, and lead *str* to grounded battery. The operation of relay 58 prevents, after the operation of register magnet 44, the operation of strike magnet 52 by opening the circuit thereof at its lower contact and armature, and also prevents, after the operation of register magnet 44, the release of wipe-out relay 22 by opening, at a second point, the circuit of the lower winding of differential relay 22. Thus, the printing mechanism will indicate the elapsed time, but in this case will not automatically restore the elapsed time meter and its own mechanism to normal. After the reading has been noted, the operator restores key 9 to its start position. The restoration of said key to its start position reoperates start relay 13. The reoperation of start relay 13 reopens the flashing circuit of lamp 19, reoperates the rotary magnet 21 to restart the rotation of the meter and release relay 20. The release of relay 20 opens, at a third point, the circuit of the lower winding of differential relay 22, releases relay 58, releases relay 39, which in turn releases magnets 40 and 44, and releases magnets af_2 to dt_2. Thus, the reading of the elapsed time meter is made, the printing mechanism is restored to normal, and the meter resumes the timing of the call after only a momentary interruption.

Also, an auxiliary wipe-out key is provided to clear any meter after a false start. This key is indicated at 64 in Fig. 1. The operation of this key, after key 9 has been operated to its strike position, closes the circuit of the lower winding of wipe-out differential relay 22, and causes the release of said relay. This circuit may be traced from the grounded contact and spring of key 64, through lead wo_1, the contact and armature of relay 20, lead *wo*, the lower winding of relay 22, contact 13 and armature 17 of relay 22, to grounded battery. The release of this relay opens its own locking circuit, opens the circuit of lamp 19, opens the operating and locking circuits of relay 20, and closes the circuit of release magnet 24 and/or the circuits of stepping magnets 78 and 79. The release of relay 20 and the operation of magnets 24, 78 and/or 79, restores all the apparatus to normal, as described above. The operator then, of course, releases key 64 and restores key 9 to the start position which starts anew the timing of the call.

This invention has been illustrated and described in connection with a system for timing telephone toll calls. However, it is to be understood that the apparatus and principles of operation disclosed are applicable to any type of measuring system in which it is desired to transmit electrically the reading of a meter or register to a printing and/or indicating mechanism, and to operate said mechanism electrically for the purpose of printing and/or indicating said reading. It is also to be understood that the meters per se or the respective sub-systems per se, in contradistinction to the disclosed system as a whole, may be used separately to accomplish the functions contemplated thereby without departing from the spirit and scope of the invention.

What is claimed is:

1. In combination, measuring apparatus, means for operating said measuring apparatus, means for controlling the operation of said measuring apparatus, as desired, automatic printing mechanism adapted to print the reading of said measuring apparatus, a plurality of conductors connecting said measuring apparatus and said printing mechanism, and means for electrically transmitting said reading to said printing mechanism by a single impulse comprising a combination of current individual to said reading flowing through a plurality of said conductors to cause said printing mechanism to print said reading.

2. In combination, measuring apparatus, means for operating said measuring apparatus, automatic printing mechanism adapted to print the reading of said measuring apparatus, means for electrically transmitting said reading to said printing mechanism and causing said printing mechanism to print said reading, and means controlled by the operation of said printing mechanism for restoring said printing mechanism and said measuring apparatus to normal.

3. In combination, measuring apparatus, means for operating said measuring apparatus, means for controlling the operation of said measuring device, as desired, electrically controlled indicating means for indicating the reading of said measuring apparatus, and means for electrically transmitting any such reading of said measuring apparatus to said indicating means by means of a characteristic impulse code individual to said reading, one or more of said codes consisting individually of a plurality of impulses, to cause said indicating means to indicate said reading.

4. In combination, measuring apparatus, means for operating said measuring apparatus, automatic printing mechanism for indicating and printing the reading of said measuring apparatus, means for electrically transmitting said reading

to said printing mechanism and causing said printing mechanism to indicate and print said reading, and means associated with said printing mechanism to cause said mechanism to indicate said reading without printing it.

5. In combination, measuring apparatus, means for operating said measuring apparatus, automatic printing mechanism for indicating and printing the reading of said measuring apparatus, means for electrically transmitting said reading to said printing mechanism and causing said mechanism to print said reading, means controlled by the operation of said printing mechanism for restoring said printing mechanism and said measuring apparatus to their normal unoperated condition, and means associated with said printing mechanism to cause said mechanism to indicate said reading without printing it, and to restore said printing mechanism to its normal unoperated condition without restoring said measuring apparatus to its normal unoperated condition.

6. In a telephone system, in combination, interconnecting circuits for establishing talking connections between two points, measuring apparatus associated with said interconnecting circuits, control means for rendering said measuring apparatus operative or inoperative as desired, automatic printing apparatus adapted to print the reading of said measuring apparatus, and means for electrically transmitting any such reading of said measuring apparatus to said printing apparatus by means of a characteristic impulse code individual to such reading, one or more of said codes consisting individually of a plurality of impulses, to cause said printing apparatus to print said reading.

7. In a telephone system, interconnecting circuits for establishing talking connections between two points, measuring apparatus associated with said interconnecting circuits, control means for rendering said measuring apparatus operative or inoperative as desired, automatic printing apparatus adapted to print the reading of said measuring apparatus, means for electrically transmitting said reading to said printing apparatus and causing said printing apparatus to print said reading, and means controlled by the operation of said printing apparatus for restoring said printing apparatus and said measuring apparatus to normal.

8. In a telephone system, interconnecting circuits for establishing talking connections between two points, measuring apparatus associated with said interconnecting circuits, control means for rendering said measuring apparatus operative, electrically controlled indicating means for indicating the readings of said measuring apparatus, and means for electrically transmitting said readings to said indicating means by means of characteristic impulse codes individual to said readings to cause said indicating means to indicate said readings, one or more of said codes consisting individually of a plurality of impulses.

9. In a telephone system, interconnecting circuits for establishing talking connections between two points, measuring apparatus associated with said interconnecting circuits, control means for rendering said measuring apparatus operative, automatic printing mechanism for indicating and printing the reading of said measuring apparatus, means for electrically transmitting said reading to said printing mechanism and causing said printing mechanism to indicate and print said reading, and means associated with said printing mechanism to cause said mechanism to indicate said reading without printing it.

10. In a telephone system, interconnecting circuits for establishing talking connections between two points, measuring apparatus associated with said interconnecting circuits, control means for rendering said measuring apparatus operative, automatic printing mechanism for indicating and printing the reading of said measuring apparatus, means for electrically transmitting said reading to said printing mechanism and causing said printing mechanism to print said reading, means controlled by the operation of said printing mechanism for restoring said printing mechanism and said measuring apparatus to their normal unoperated condition, and means associated with said printing mechanism to cause said mechanism to indicate said reading without printing it and to restore said printing mechanism to its normal unoperated condition without restoring said measuring apparatus to its normal unoperated condition.

11. In a telephone system, interconnecting circuits for establishing talking connections between two points, elapsed time measuring apparatus individual to each interconnecting circuit, control means individual to said measuring apparatus and said interconnecting circuits for starting said measuring apparatus into operation, means associated with said interconnecting circuits for automatically stopping the operation of said measuring apparatus upon the termination of a talking connection, automatic printing mechanism common to a plurality of said interconnecting circuits and measuring apparatus and adapted to print the elapsed time measured by said measuring apparatus, and means for causing said printing mechanism to print the elapsed time measured by said measuring apparatus, the operation of said printing mechanism being adapted to automatically restore itself and said measuring apparatus to normal.

12. In combination, measuring apparatus for timing operations, means for operating said measuring apparatus, means for stopping the operation of said measuring apparatus at the termination of each operation being timed, automatic printing mechanism adapted to print the reading of said measuring apparatus, means for electrically transmitting any such reading of said measuring apparatus to said printing mechanism by means of a characteristic impulse code individual to such reading, one or more of said codes consisting individually of a plurality of impulses, and means responsive to such code for causing said printing mechanism to print said reading.

13. In combination, measuring apparatus, means for operating said measuring apparatus, automatic printing mechanism adapted to print the reading of said measuring apparatus, means for electrically transmitting said reading to said printing mechanism and causing said printing mechanism to print said reading, and means controlled by the operation of said printing mechanism for restoring said measuring apparatus to normal.

14. In combination, measuring apparatus, means for operating said measuring apparatus, means for controlling the operation of said measuring apparatus, signaling means for indicating the cessation of the measuring operation, automatic printing mechanism adapted to print the reading of said measuring apparatus, means for electrically transmitting said reading to said printing mechanism and causing said printing

mechanism to print said reading, means controlled by the operation of said printing mechanism for restoring said printing mechanism and said measuring apparatus to normal, and signaling means for indicating that said printing mechanism and said measuring apparatus have been restored to normal.

15. In combination, measuring apparatus, means for operating said measuring apparatus, electrically controlled recording means for indicating and recording the reading of said measuring apparatus, and means for electrically transmitting said reading to said recording means and causing said recording means to indicate said reading without recording it.

16. In combination, measuring apparatus including a plurality of dial wheels, means for operating said measuring apparatus, automatic printing mechanism adapted to print the reading of said measuring apparatus, and means for electrically transmitting the readings of all of said dial wheels to said printing mechanism simultaneously and causing said printing mechanism to print said readings.

17. In combination, measuring apparatus including a plurality of dial wheels, means for operating said measuring apparatus, automatic printing mechanism adapted to print the reading of said measuring apparatus, and means for electrically transmitting the readings of all of said dial wheels to said printing mechanism simultaneously and causing said printing mechanism to print all of said readings simultaneously.

18. In combination, measuring apparatus, means for operating said measuring apparatus, means for controlling the operation of said measuring apparatus as desired, automatic recording mechanism adapted to record the measurements designated by said measuring apparatus, and means for electrically transmitting said designated measurements to said recording mechanism by means of characteristic impulse codes individual to said designated measurements to cause said recording mechanism to record said designated measurements, one or more of said codes consisting individually of a plurality of impulses.

19. In combination, a measuring device including a plurality of counting units, means for operating said measuring device, automatic recording apparatus adapted to record the readings of said counting units, and means for electrically transmitting the readings of a plurality of said counting units to said recording apparatus simultaneously and causing said recording apparatus to record said readings.

20. In combination, measuring apparatus, means for operating said measuring apparatus, automatic recording apparatus adapted to record the reading of said measuring apparatus, means for stopping the operation of said measuring apparatus and maintaining said measuring apparatus in its operated position for an indefinite period of time, if desired, and means for later transmitting said reading electrically to said recording apparatus and causing said recording apparatus to record said reading.

21. In combination, a plurality of measuring devises, means for operating said measuring devices, means for selectively controlling the operation of said measuring devices as desired, automatic recording apparatus common to said measuring devices and adapted to record the readings of said measuring devices, and means for selectively transmitting the readings of said measuring devices to said recording apparatus by means of characteristic impulse codes individual to said readings, one or more of said codes consisting individually of a plurality of impulses, to cause said recording apparatus to record selectively said readings.

22. In a telphone system, in combination, interconnecting circuits for establishing talking connections between two points, measuring apparatus associated with said interconnecting circuits, control means for rendering said measuring apparatus operative or inoperative as desired, signaling means associated with said interconnecting circuits, means controlled from the calling point for intermittently operating said signaling means and for stopping the operation of said measuring apparatus and maintaining it in its operated position, means controlled by the operator for re-starting said measuring apparatus, automatic recording mechanism adapted to record the measurement designated by said measuring apparatus, and means for causing said recording mechanism to record said designated measurement.

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