Sept. 2, 1941. H. ANGEL ET AL 2,254,814

TELEGRAPH SIGNAL STORAGE APPARATUS

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FIG. 1

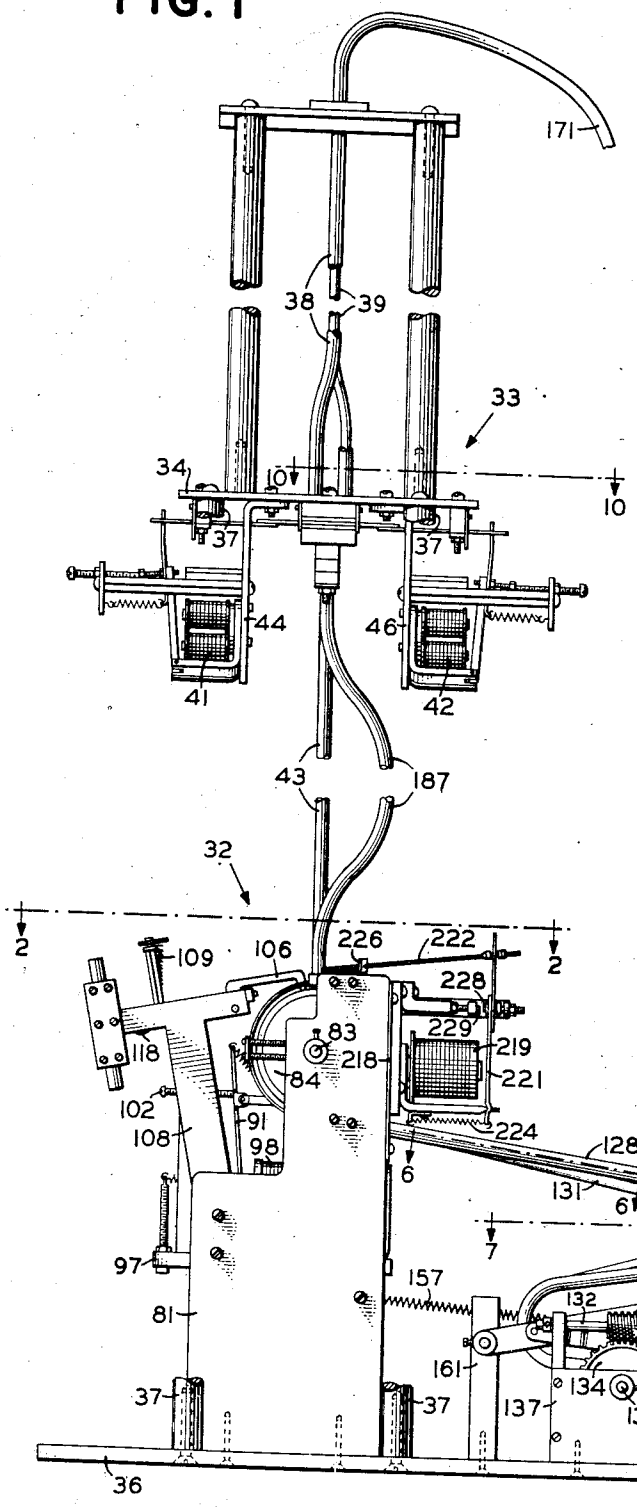
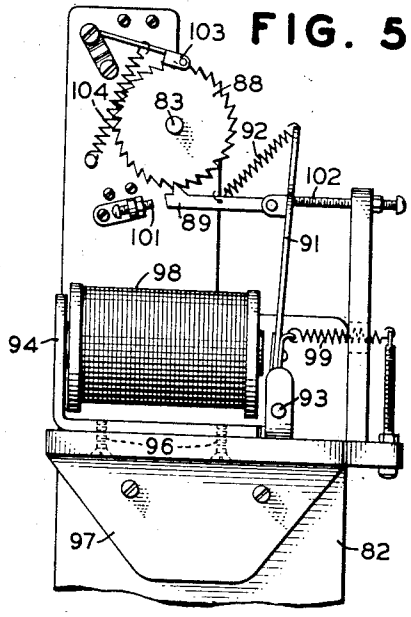


FIG. 5



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FIG. 2

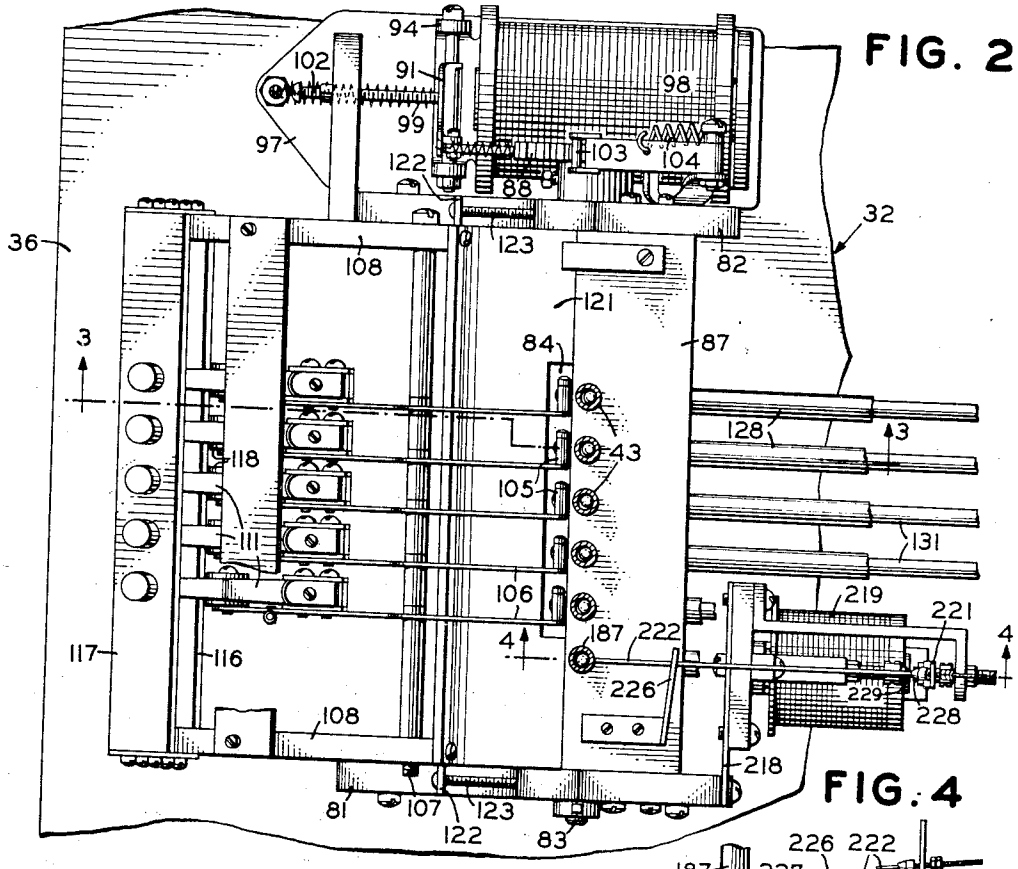


FIG. 3

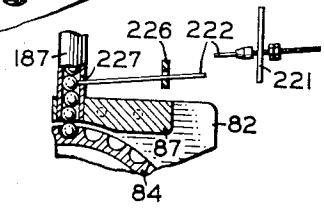


FIG. 4

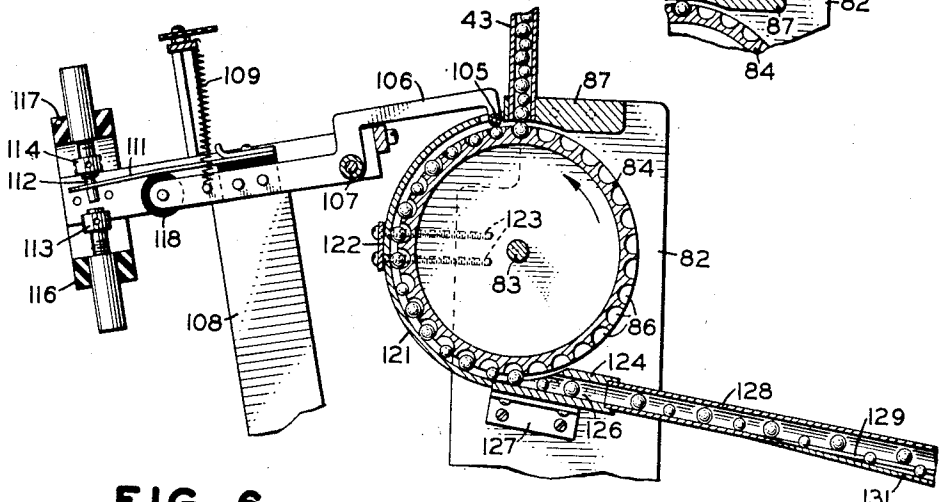
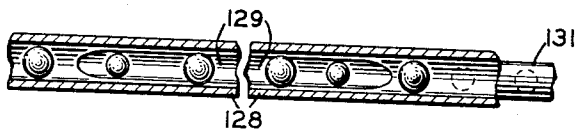


FIG. 6



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FIG. 7

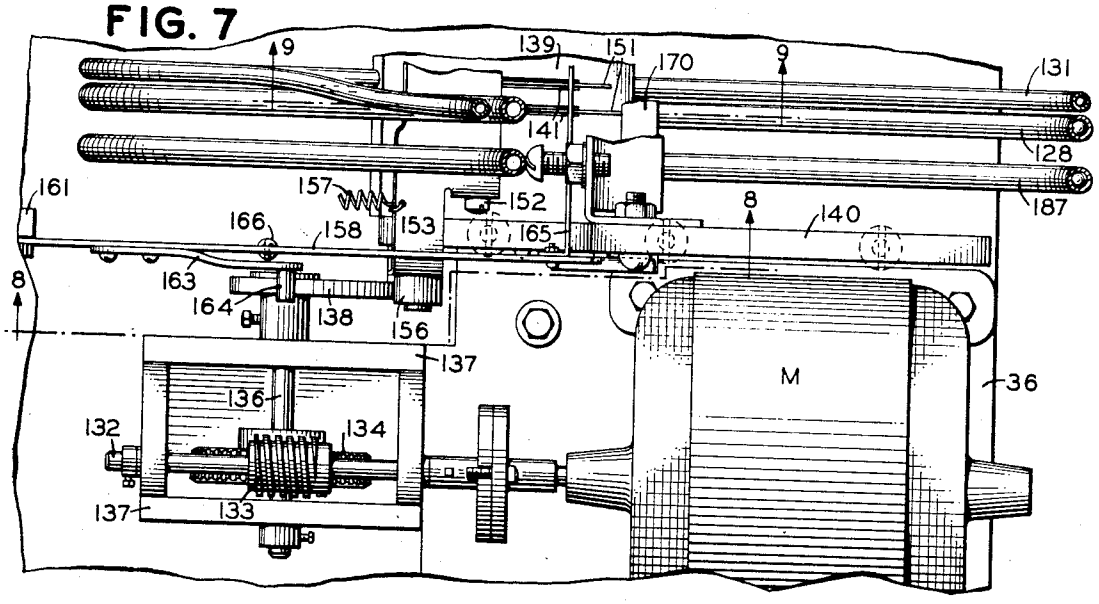


FIG. 8

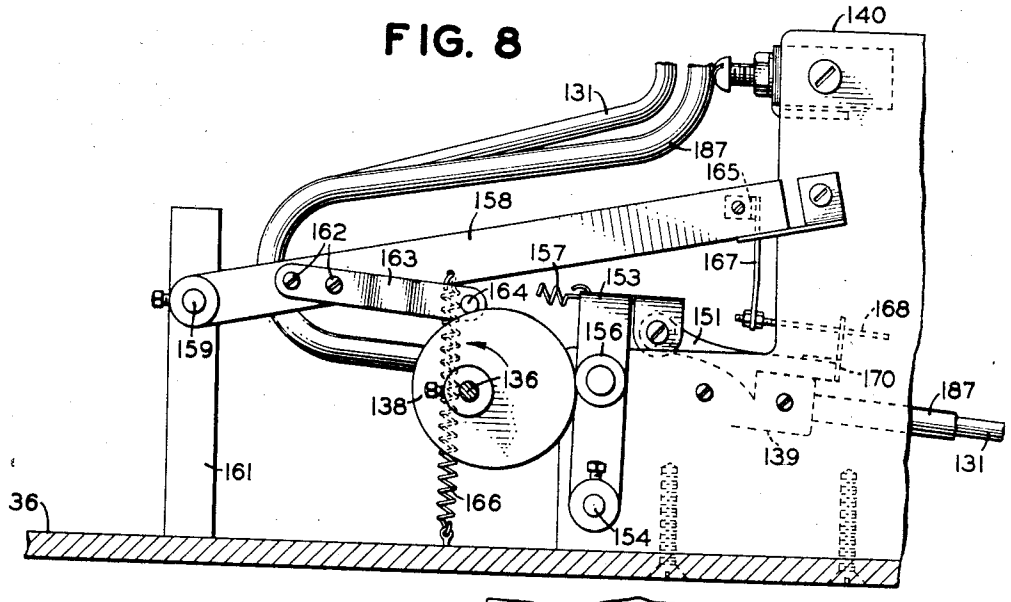
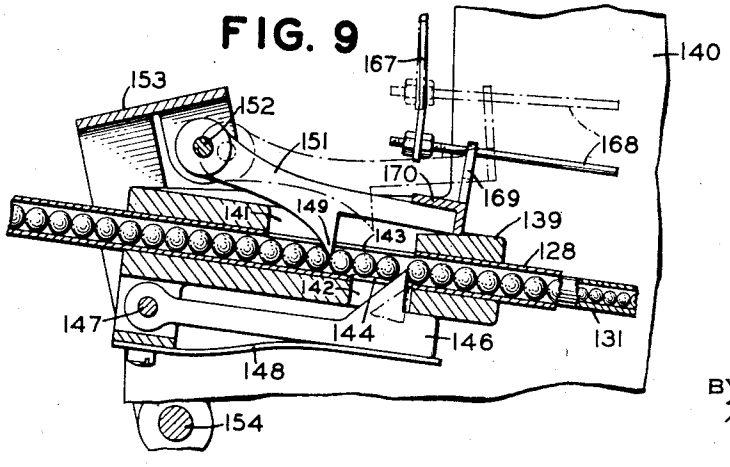


FIG. 9



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TELEGRAPH SIGNAL STORAGE APPARATUS

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FIG. 13

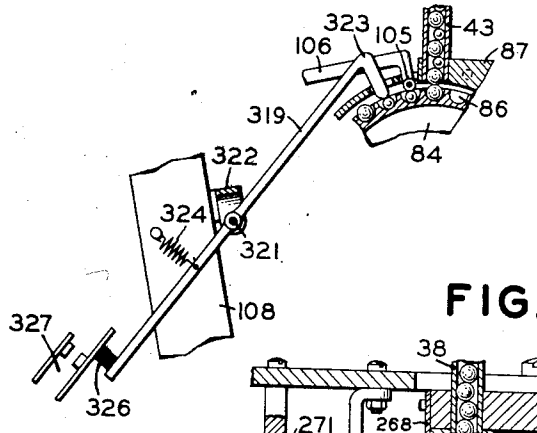


FIG. 14

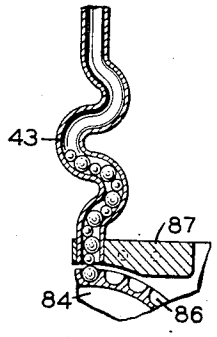


FIG. 12

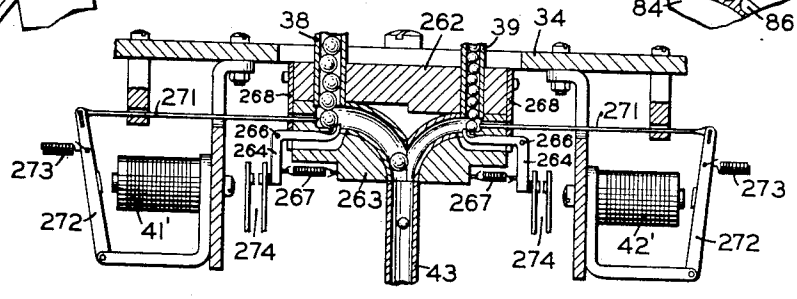


FIG. 11

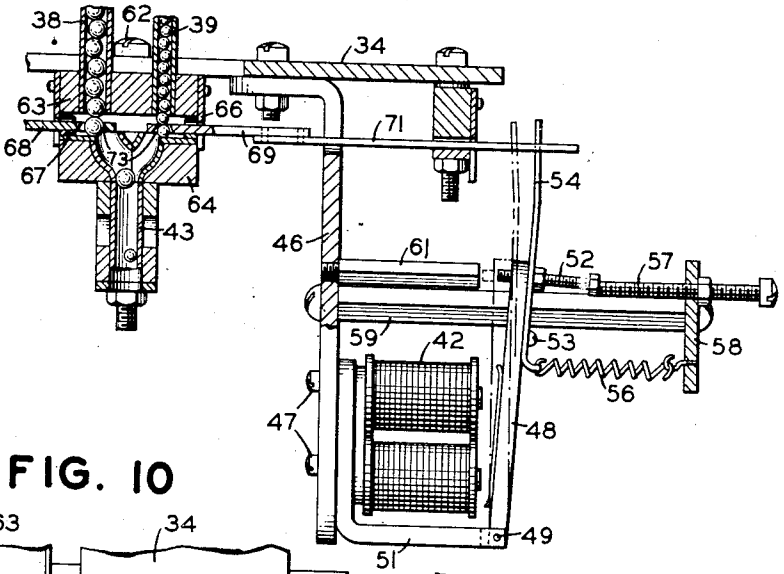
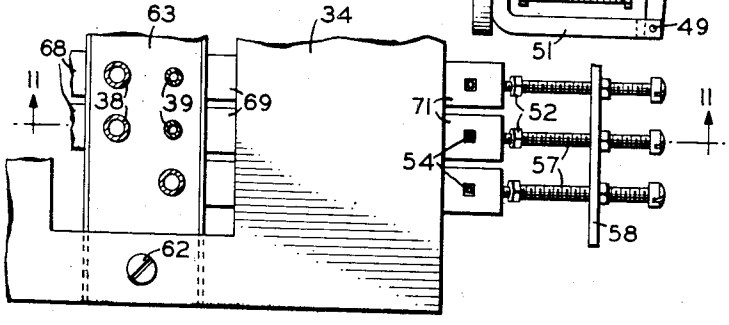


FIG. 10



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FIG. 15

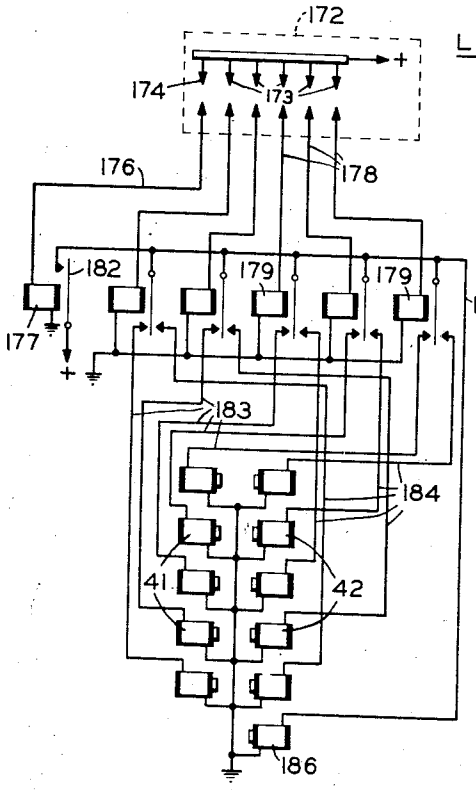


FIG. 16

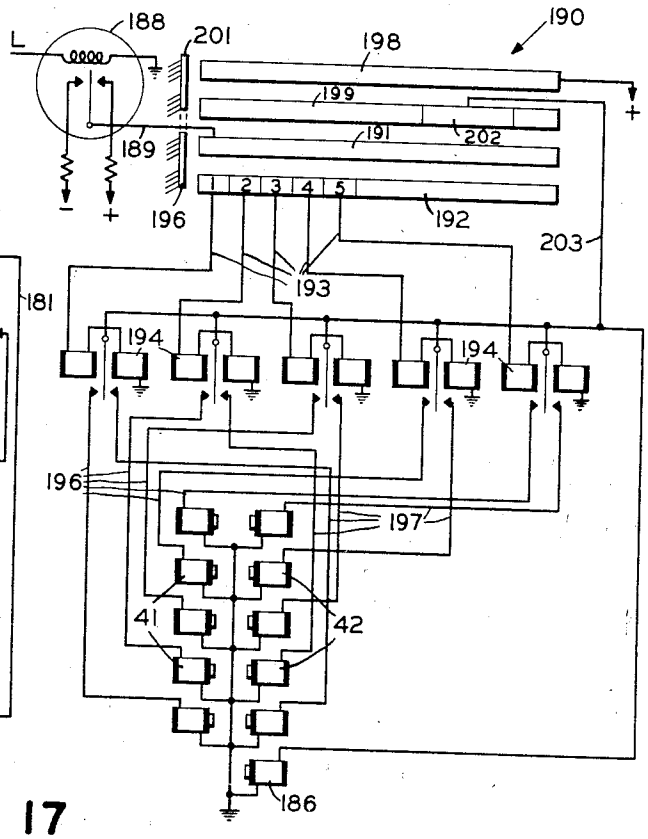
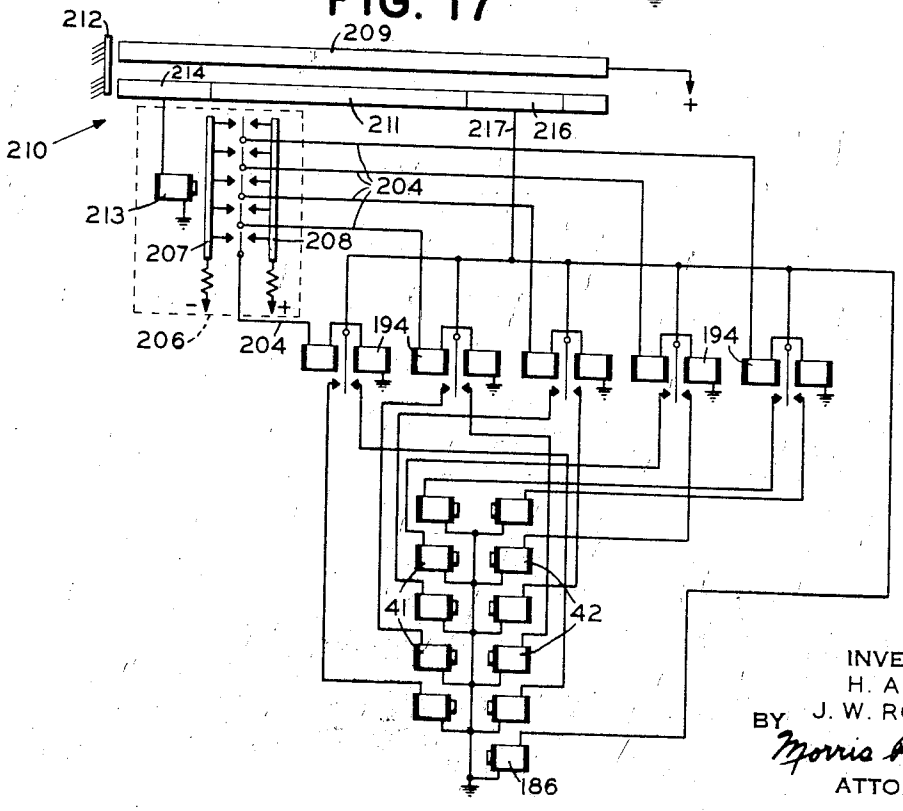


FIG. 17



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FIG. 18

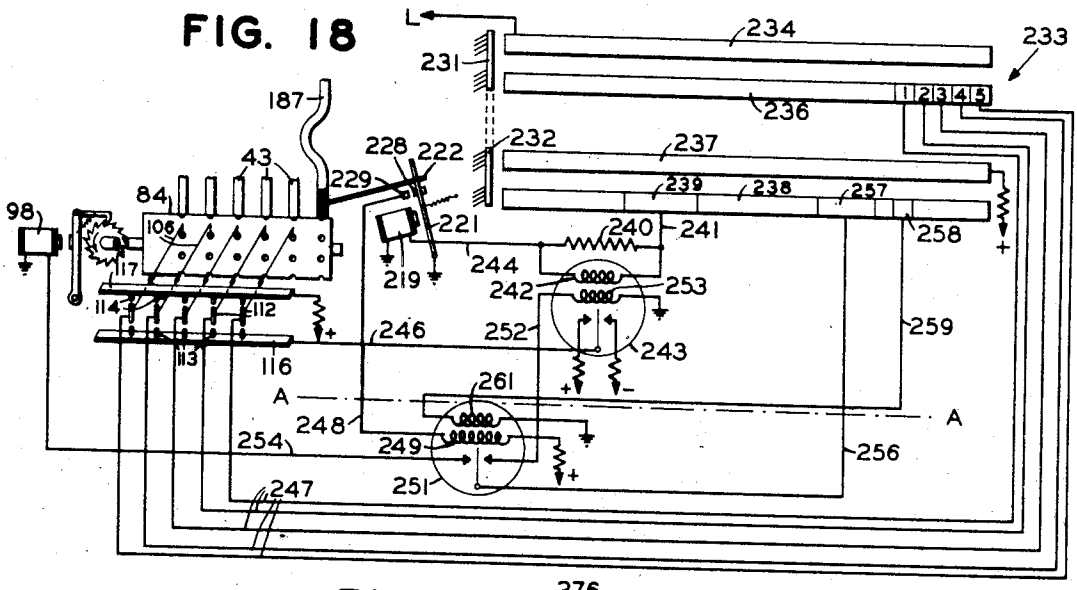


FIG. 19

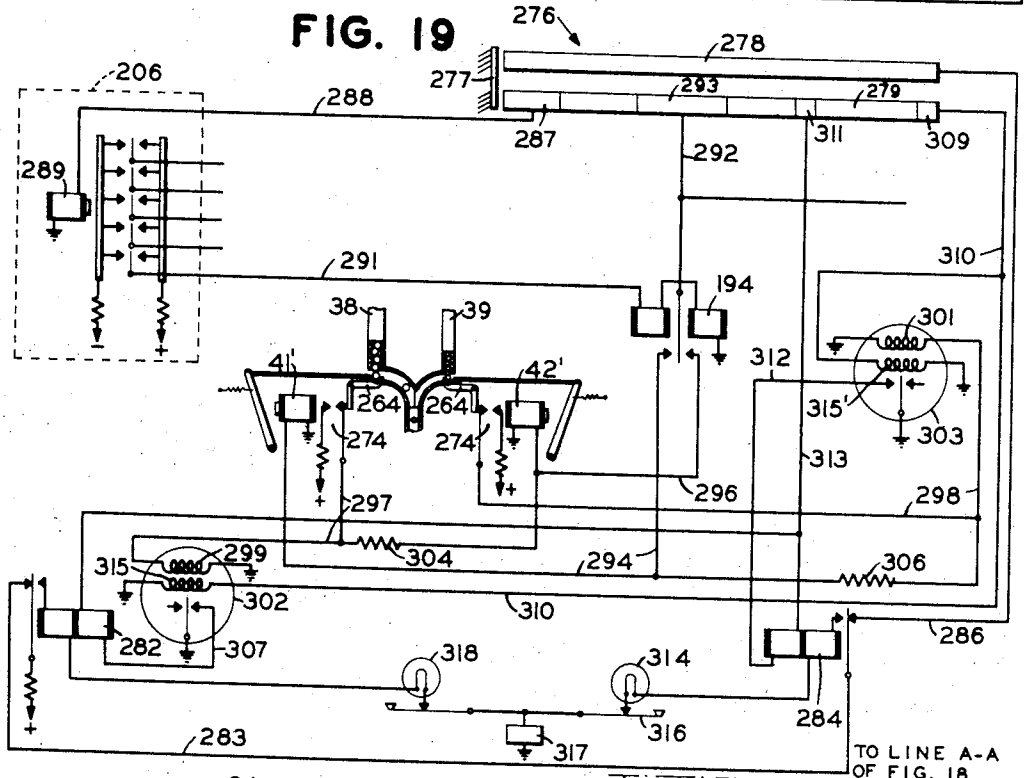
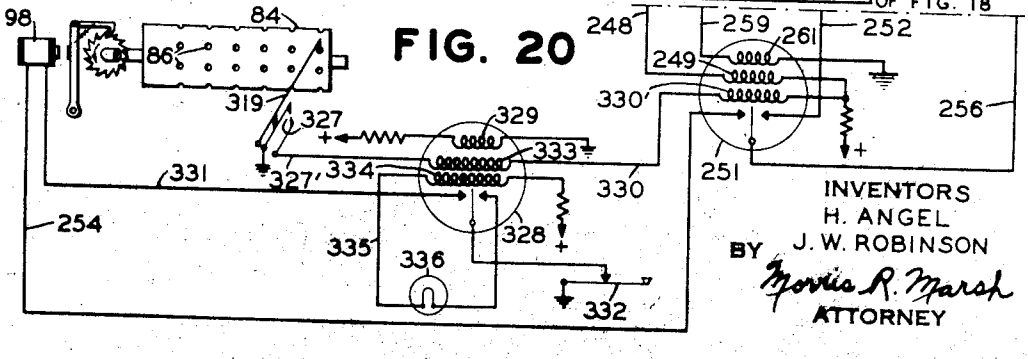


FIG. 20



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2,254,814

UNITED STATES PATENT OFFICE

2,254,814

TELEGRAPH SIGNAL STORAGE APPARATUS

Herbert Angel, Brooklyn, and James W. Robinson, Far Rockaway, N. Y., assignors to The Western Union Telegraph Company, New York, N. Y., a corporation of New York

Application December 9, 1939, Serial No. 308,326

30 Claims. (Cl. 178—17.5)

This invention relates primarily to telegraph signal storage apparatus, and more particularly to apparatus for storing for a variable length of time telegraph signals which may be received, for example, from any one of a plurality of sources, such as a keyboard, a tape transmitter, or over a communicating channel from a distant point. The apparatus is controlled by the received signals to select and/or arrange in predetermined order in accordance with the received signals comparatively small mechanical elements which have as many distinguishing characteristics as there are line conditions in the telegraph signals. These mechanical elements are stored in the arrangement in which they are selected and finally employed to control a transmitting apparatus to transmit telegraph signals which are representative of the distinguishing characteristics of the mechanical elements.

In accordance with the preferred embodiment of the invention the mechanical storing elements are small balls, and the distinguishing characteristics of the balls are their size and where the signals are of two different line conditions there are two different sizes of balls, one size representing one line condition while the other size ball represents the other line condition.

In the transmission of telegrams and in various telegraph systems, there are many instances where for obvious reasons it is necessary or desirable that the telegraph signals be stored for a length of time. Heretofore, the storing of the signals was generally effected by a perforated tape, the received signals operating a perforator to perforate the tape in accordance with the received signals in a manner well known in the art. The perforated tape thus constituting the means for storing the telegraph signals, it later being used to control a tape transmitter for transmitting to an outgoing circuit. Obviously the tape can be used but once and constitutes a considerable expense in the course of a year and besides is likely to become damaged, which would result in the transmission of erroneous signals. Such a system also requires more or less complicated perforators and transmitters, which require considerable maintenance.

Accordingly, one of the objects of this invention is to provide an apparatus for arranging or selecting small mechanical elements in accordance with received telegraph signals which may be stored for variable lengths of time and ultimately employed to control a transmitting means to convert the mechanical elements back into telegraph signals.

Another object of the invention is to provide apparatus for selecting and arranging the mechanical elements in the proper order and reconverting the mechanical elements back into telegraph signals that is rapid and accurate in operation.

Another object of the invention is to provide an apparatus that may be used as a signal repeater in which there is no definite tie-up between the speeds of the received signals and the transmitted signals.

Another object of the invention is to provide an alarm device which is operable when a mechanical element is not deposited or placed in the storage means for each signaling impulse of a received code group of signals.

Another object of the invention is to provide an alarm device which is operable when other than the proper number of mechanical elements representative of a complete code group of signals are not removed from the storage means.

These and various other objects of the invention will be apparent hereinafter when taken in conjunction with the accompanying drawings, in the latter of which:

Fig. 1 is an elevational view of the invention showing the selecting apparatus, storage tubes, the transmitting apparatus and the elevating apparatus for returning the mechanical elements or small balls as in the preferred embodiment of the invention to the selector mechanism;

Fig. 2 is a horizontal sectional view taken substantially on line 2—2 of Fig. 1, showing the transmitting apparatus;

Fig. 3 is a fragmentary vertical sectional view taken substantially on line 3—3 of Fig. 2, showing one of the units of the transmitting mechanism;

Fig. 4 is a fragmentary vertical sectional view taken substantially on line 4—4 of Fig. 2;

Fig. 5 is an end view of the transmitting drum stepping magnet;

Fig. 6 is a fragmentary horizontal sectional view taken on line 6—6 of Fig. 1;

Fig. 7 is a fragmentary horizontal sectional view taken on line 7—7 of Fig. 1;

Fig. 8 is a fragmentary vertical sectional view taken on line 8—8 of Fig. 7;

Fig. 9 is a fragmentary vertical sectional view taken on line 9—9 of Fig. 7;

Fig. 10 is a fragmentary horizontal sectional view taken on line 10—10 of Fig. 1;

Fig. 11 is a fragmentary vertical sectional view taken on line 11—11 of Fig. 10, showing part of the elements of a unit of the selector mechanism;

Fig. 12 is a vertical sectional view of a modification of a selector unit;

Fig. 13 is a fragmentary sectional view of one of the units of the alarm operating device in the transmitter;

Fig. 14 is a vertical sectional view of the lower section of one of the storage tubes;

Fig. 15 is a wiring diagram showing the circuits for controlling the selector mechanism when associated with a keyboard mechanism;

Fig. 16 is a wiring diagram showing the circuits for controlling the selector mechanism from a line relay;

Fig. 17 is a wiring diagram showing the circuits for controlling the selector mechanism from a tape transmitter;

Fig. 18 is a wiring diagram showing the circuits for controlling the transmitting mechanism;

Fig. 19 is a wiring diagram showing the circuits for controlling the modified selector mechanism of Fig. 12; and

Fig. 20 is a wiring diagram showing the circuits associated with one of the units of the alarm device on the transmitting mechanism.

In the preferred embodiment of the present invention there are as many complete selecting units as there are selecting intervals in each of the employed code groups of signals and therefore if each code group has five selecting intervals, there will be five complete selecting units. Each of the selecting units has leading to it two so-called supply tubes with one size ball in one tube and another size in the other. These tubes invariably have a supply of their respective size of balls therein, the balls being placed therein by the elevator mechanism hereinafter described in detail. The movement of the balls through the various units with the exception of the elevator mechanism is dependent upon gravity or the weight of the balls, accordingly the supply tubes for each selector unit extend above the unit, however, it will be apparent hereinafter that various other forces such as air pressure, magnetic means, etc. could be employed to move the balls. Extending from the underside of each of the selector units is a so-called storage tube, it being of such a size as to permit the free movement of both sizes of balls therein while at the same time preventing jamming on the passage of one ball past another. Thus these storage tubes keep the balls in alignment and in the same order in which they are deposited therein. The selector units are adapted on each operation thereof to remove either a marking or a spacing ball from either one or the other of the supply tubes located thereabove and deposit it in the storage associated tube. The storage tubes are of sufficient length to accommodate a comparatively large number of balls and may be curved or formed into helixes, etc. in order to increase the storage capacity for a given distance between inlets and outlets thereof.

At the outlet of the storage tubes is a drum in which are formed a series of circumferential rows of pockets which are adapted to pass beneath the ends of the tubes to remove the balls from the storage tubes one at a time from each tube and convey them past transmitting mechanism to transmit, according to their size, representative signals. The transmitting drum in the preferred embodiment is intermittently rotated an amount equal to the circumferential distance between consecutive pockets therein by a magnet. The transmitting mechanism comprises pivoted arms one end of which is in alignment with each of the circumferential rows of pockets in a transmitting drum. Contacts on the transmitting arm are operated so as to make contact with one stop when a large or marking ball is in an associated pocket in a transmitting drum and to remain on contact with another stop when a smaller or spacing ball is in the associated transmitting drum pocket. As the balls of both sizes leave the transmitting drum, they are separated into their respective groups and then proceed to the elevating mechanism. The elevating mechanism comprises cam operated pawls which push the balls up return tubes to their associated supply tubes.

The selecting mechanism is adapted to be operated by signals from any one of a number of different sources, such as a keyboard, a tape transmitter or from signals received over a channel of communication and although the fundamental operation of the selector mechanism in all instances is somewhat the same, each have individual conditions and the above three are hereinafter described in detail.

It will be apparent that if for some reason one or more of the units of the selector mechanism on a cycle of operation thereof should happen to fail and not place a ball in their storage tubes and each of the other units operated and did place a ball in their respective storage tubes, each following group of balls removed from the storage tubes would represent a part of two received code groups and obviously be incorrect. Similarly, if the transmitting unit failed to remove a ball from one of the storage tubes on each operation thereof, each succeeding signal transmitted would be apt to be incorrect. Accordingly, alarm or safety devices are provided which signal an attendant on the failure of the selector mechanism to deposit a ball in each of the storage tubes on each cycle of operation thereof and on the failure of the transmitting unit to remove the proper number of balls from the storage tubes on each cycle of operation thereof. These various features of the invention and the structural arrangement of the elements thereof will hereinafter be described in detail.

Referring first to Fig. 1, the elevating mechanism, the transmitting mechanism and the selecting mechanism are indicated in general by reference numerals 31, 32 and 33 respectively. The selecting mechanism comprises a horizontal mounting plate 34 which is supported from the base plate 35 by posts such as 37. The posts 37 are of suitable length to provide sufficient storage space between the selecting and transmitting units. The lower ends of the marking and spacing supply tubes 38 and 39, respectively, extend through the plate 34 and supply the selector mechanism with the marking and spacing balls.

Each unit of the selector mechanism comprises marking and spacing magnets 41 and 42, respectively, the operation of which removes a ball from either the marking or spacing supply tubes 38 and 39 and places it in the associated storage tube 43 in a manner hereinafter described.

The marking and spacing magnets 41 and 42 are supported on angle brackets 44 and 45 respectively attached to the underside of the

mounting plate 34 on opposite sides of the storage tubes 43. An enlarged sectional view of part of the elements of a selector unit is shown in Fig. 11. The spacing selector magnet such as 42, Fig. 11, is attached by screws such as 47 to the depending sections of the bracket 46. Associated with the magnet 42 is an armature lever 48 which is pivoted at its lower end on a pin 49 supported in the magnet bracket 51. Attached to the upper free end of the armature lever 48 by screws such as 52 and 53 is an upwardly extending finger 54. A spring 56 attached to the finger 54 normally holds the armature lever 48 and finger 54 in their retracted position with the head of the screw 52 against the end of an adjustable stop screw 57 supported in a plate 58 which also serves for a mounting for the spring 56. The plate 58 is supported on studs 59 extending horizontally from the magnet mounting plates 46. A stud 61 mounted in the plate 46 cooperates with the ends of the screw 52 in the armature lever 48 to limit the operated position thereof. The associated marking magnet 41 has a similar arrangement of elements and two such magnets, a marking and a spacing, comprise a unit of the selecting mechanism.

Supported from adjacent the center of the underside of the selector mechanism mounting plate 34 by screws 62 are two horizontal members 63 and 64. Spacers such as 66 and 67 between the members 63 and 64 form spaces which permit the movement of horizontal marking and spacing shuttles such as 68 and 69 between the blocks. The lower ends of the marking and spacing supply tubes 38 and 39 respectively are fixed in the block 63 while the upper ends of associated storage tubes 43 which are Y-shaped, are anchored in the block 64. The horizontal shuttles 68 and 69 are interposed between the lower ends of the supply tubes and the Y and the upper ends of the storage tubes and have affixed thereto operating arms 71. The arms 71 are properly guided for longitudinal movement and have holes adjacent the outer ends thereof through which extends the finger 54 of associated selecting magnets 41 and 42.

The inner ends of the shuttles 68 and 69 have holes 73 therein and in the normal retracted position of the associated selector magnet armatures the holes 73 are directly beneath the lower ends of associated supply tubes 38 and 39. The holes 73 are of such a size as to permit the free passage of their respective sizes of associated balls therethrough without excessive play and are tapered from the undersides for reasons hereinafter described. Thus when the shuttles 68 and 69 are in their retracted or normal positions, a ball from associated supply tubes 38 and 39 will be in the holes 73 there but these balls are prevented from passing into the Y at the upper end of the associated storage tube 43 as the upper ends of the Y are slightly out of line with the lower ends of the supply tubes.

For each signal impulse of a code either the marking or spacing selector magnet 41 or 42 respectively, Fig. 1, of the associated unit will be operated to move its shuttle 68 or 69 toward the center and in so doing moves the associated ball in the hole 73, Fig. 11, therein over the upper end of the Y in the storage tube. The ball in the actuated shuttle thereupon drops down into the storage tube and the rest of the balls in the supply tube are prevented from entering the storage tube as the solid part of the shuttle will be under the end of the supply tube when the shuttle is operated. As the shuttle returns to its normal position on the deenergization of its associated operating magnet, the hole 73 therein is again placed beneath the end of the supply tube and another ball drops therein. Thus each time one of the shuttles 68 or 69 of a selector unit is operated, a ball of one size or the other depending upon which magnet is operated is deposited in storage tube 43.

When the selector unit operates at normal telegraph speeds the interval of time allotted to each signal impulse is very short and therefore the selecting magnets 41 and 42 are only momentarily operated. In order to insure that the balls in the operated shuttles will drop out of the holes 73 therein and not be pulled back or returned to their original position on the return of the shuttles to normal, the holes in the shuttle are tapered from the underside. Therefore, as a shuttle is operated, the sloping edge of the hole 73 imparts a downward motion to the ball in the shuttle and accelerates it into movement. Thus the marking and spacing balls are selected and deposited in the storage tubes 43 in accordance with the operation of the signals received on their respective operating magnets. The manner in which the marking and spacing signals are distributed to their respective marking and spacing magnets will hereinafter be described in connection with the circuits for controlling the operation of the selector unit.

The storage tubes 43, Fig. 1, in addition to storing and keeping the balls in the alignment in which the selector arranged them also conveys the balls to the transmitting mechanism 32. As hereinbefore stated the transmitting mechanism comprises means for removing the balls from the storage tubes 43 and transmitting groups of code impulses representative of the making and spacing balls. The transmitting mechanism 32, Figs. 1 and 2, comprises a pair of vertical mounting plates 81 and 82 to which is mounted the various elements of the transmitting mechanism. Suitably journaled in the plates 81 and 82 is a shaft 83 which has affixed thereto for rotation therewith a drum 84. The drum 84 is of substantial diameter and extends substantially the entire distance between the plates 81 and 82. Arranged around the circumference of the drum 84 are a series of cup shaped pockets such as 86 Fig. 3. The pockets 86 are in a series of circumferential and axial rows, there being one more circumferential row than there are storage tubes 43, the extra circumferential row being provided for control purposes hereinafter described. A horizontal member 87 extending between the vertical mounting plates 81 and 82 has the lower ends of the storage tubes 43 anchored therein and serve to keep the lower ends of the storage tubes in alignment with their associated circumferential rows of pockets on the drum 84. The size of the pockets 86 on the drum are such that they permit the smaller spacing balls to enter therein substantially their full diameter while the larger marking balls protrude an appreciable amount beyond the periphery of the drum 84.

Affixed to the one end of the drum shaft 83 for rotation therewith is a ratchet 88, Figs. 2 and 5, which serves to rotate the drum 84 in a manner to be described. In operative relation with the underside of the ratchet 88 is a pawl 89. The pawl 89 is pivoted on the upper end of an armature lever 91 and a spring 92 attached to the pawl and an extension of the armature lever

holds pawl 89 in engagement with the teeth of the ratchet 88. The lower end of the armature lever 91 is pivoted at 93 in a magnet bracket 94 which is attached by screws 96 to a bracket 97 extending from the outside of the vertical mounting plate 82. A magnet 98 in operative relation with the armature lever 91 serves when energized to pivot the armature lever in a counterclockwise direction against the action of a retractile spring 99. When the armature lever 91 is thus operated the pawl 89 which is in engagement with a tooth on ratchet wheel 88 steps the same an amount equal to the distance between consecutive teeth. Adjustable stops 101 and 102 in operative relation with the pawl 89 and the armature 91 respectively limit the stroke of the pawl. A detent 103 in operative relation with the upper side of the ratchet wheel 88 is biased by a spring 104 to prevent rotation of the ratchet 88 in a reverse direction on the back stroke of the pawl 89.

The ratchet wheel 88 in the preferred embodiment has the same number of teeth as there are axial rows of pockets 86 in the drum 84, Fig. 3, and the relative positions of the ratchet 88 and drum 84 upon the shaft 83 are such that when the ratchet is stopped in one of its rest positions, an axial row of pockets in the drum 84 is substantially directly beneath the lower ends of the storage tubes 43. Accordingly if there are no balls in the drum 84 or in the lower ends of the storage tubes 43 the first groups of balls selected by the selector mechanism 33 fall down the tubes 43 and into the row of pockets in the drum in alignment with the ends of the tubes 43. Following groups of selected balls drop into the storage tubes 43 and pile up one upon the other in the same order in which they are selected and after a few groups are deposited in the storage tube and have reached the lower ends thereof a control means hereinafter described initiates the rotation of the drum 84. The first step of the drum 84 moves the first group of balls in the pockets 86 from underneath the storage tubes and over into engagement with rollers 105 on the right hand ends of pivoted transmitting levers 106. This movement of the drum 84 places the next axial row of pockets 86 beneath the storage tubes 43 and permits the next group of balls to enter this row of pockets. The levers 106 are pivoted adjacent their centers on a rod 107 which is supported in the right hand arms of T-shaped brackets 108 extending from the mounting plates 81 and 82. Retractile springs 109 attached to the levers 106 tend to pivot the same in a clockwise direction and hold the rollers 105 on the right hand ends thereof in engagement with the balls in the first axial row of pockets in the drum 84 beyond discharge point of the storage tube 43. Secured to each of the levers 106 at the left of the pivot points 107 are flexible members 111. On the left hand end of the flexible members 111 are movable contacting elements 112 with associated stationary markings and spacing contact stops 113 and 114 respectively. The contact stops 113 and 114 are carried in insulating members 116 and 117 supported from the T-shaped brackets 108. Rollers such as 118 carried in the left hand end of the levers 106 assist in moving the flexible members 111.

The contact stops 113 and 114 are so positioned relative to the contacting element 112 so that with a small spacing ball in the pocket of the drum associated with the roller 105 on the lever 106, the element 112 will make contact with the stop 114. Similarly with a large marking ball in the pocket of the drum, the lever 106 is pivoted in a counterclockwise direction so that the element 112 makes contact with the stop 113. Thus the levers 106 are operated in accordance with the size of the balls in the axially row of pockets beneath the right hand ends of the levers 106. The levers 106 in turn operate the contacting elements 112 to contact with either the stops 113 or 114. While the contacting elements 112 are thus operated in accordance with the size of the balls in the row of pockets in operative relative with the right hand ends of the levers 106, a group of impulses representative of the position of the levers 106 is transmitted. The circuits from the contacting element 112 and the stops 113 and 114 and the manner in which a group of code impulses representative of the groups of balls are transmitted will hereinafter be described.

As the drum 84 continues to rotate or step a predetermined part of a revolution on each operation or energization of the magnet 98 successive groups of balls are removed from the storage tubes 43. A group of balls comprises one from each of the storage tubes 43. After passing beneath the rollers 105 on the right hand end of the transmitting levers 106 the balls move with the drum 84 to a discharge point which is preferably located at the underside of the drum substantially diametrically opposite the ends of the storage tubes 43. A shield 121 curved around the left hand half of the drum 84 keeps the balls in the pockets 86 of the drum until they reach the discharge point. The shield 121 is held in place by a strap 122 which is supported by screws 123 threaded into the vertical mounting plates 81 and 82. At the discharge point of the balls from the drum 84 is a member 124 which has a series of holes 126 therein in alignment with the circumferential rows of pockets on the drum 84. As the drum 84 rotates and the balls reach the discharge point they drop into the holes 126 and therefore the pockets 86 in the drum 84 on the right hand side thereof as seen in Fig. 3, are empty and adapted to have other balls deposited therein when they are again rotated beneath the ends of the storage tubes 43. The member 124 is supported between the vertical mounting plates 81 and 82 by brackets such as 127 and the right hand end of the member 124 is recessed to engage and support the left hand ends of associated return and separating tubes 128.

The holes 126 in the member 124 and the return tubes 128 slope at a slight angle away from the drum 84 and therefore the balls on leaving the drum roll down these return tubes 128. Formed in the undersides of the return tubes 128 are slots 129, Fig. 6, which are of sufficient width to permit the smaller spacing balls to pass therethrough while at the same time preventing the larger marking balls passing therethrough. Thus as the marking and spacing balls roll down the inclined tubes 128 the smaller spacing balls drop through the slots 129 while the larger marking balls continue in the tube 128. The slot 129 in the underside of the tube 128 is associated with the entrance to a tube 131 which confines the smaller spacing balls. Thus the two different sizes of balls are separated and placed in the return tubes 128 and 131 and the next operation to be performed thereon is to elevate and deposit them in their

associated supply tubes 38 and 39, Figs. 1 and 11. This operation on the balls is performed by the so-called elevating mechanism indicated in general by reference numeral 31, Fig. 1, and a description of the elements thereof and their operation will now be given.

The power for elevating the balls is supplied from a constantly rotating motor M which has coupled to the shaft thereof for rotation therewith a counter-shaft 132, Figs. 1 and 7. The counter-shaft 132 has fixed thereon a worm gear 133 and is adapted to mesh with a worm wheel or gear 134 located directly therebelow. The wheel 134 is fixed for rotation therewith to a shaft 136 which is journaled in plates 137 secured to the base 36. Also fixed to the shaft 136 adjacent one end thereof is a disc cam 138 which operates the elevating mechanism in the manner hereinafter described.

Where the balls are separated into their respective sizes the tubes 131 for confining the smaller spacing balls are directly beneath the tubes 128 that confine the larger marking balls. The tubes 128 and 131 have two substantial vertical hairpin bends therein and the tubes 131, shown best in Fig. 7, are displaced a slight amount in a horizontal direction relative to the tubes 128 so that in the lower sections thereof all the tubes 128 and 131 are in the same plane. The tubes 128 and 131 are held in horizontal alignment one with the other adjacent their lowermost point by a horizontal member 139, Figs. 7, 8 and 9 which is supported between mounting plates such as 140. The horizontal member 139 has holes therein through which extends the return tubes 128 and 131 and above and below each of the tubes are openings 141 and 142 respectively in the member 139. The openings 141 and 142 are in alignment with narrow slots 143 and 144 respectively located in the upper and lower parts on the tubes 128 and 131. Extending through the openings 142 and slots 144 in the underside of the member 139 and tubes 128 and 131 are retaining pawls 146. These retaining pawls 146 are pivoted adjacent their left hand ends on a common rod 147 and serve to prevent the movement of the balls in associated tubes in a leftwardly direction as will hereinafter be described. Springs 148 associated with the retaining pawls 146 bias them into a normal position. Extending through the slot 143 in the upper sides of the tubes 128 and 131 are depending projections 149 of operating pawls 151. The operating pawls 151 are pivoted on a common rod 152 supported in a bail member 153 which is in turn pivotally mounted at its lower ends on a rod 154 in brackets 140. A cam follower 156 pivotally mounted on one of the arms of the bail member 153 is in operative relation with the periphery of the above mentioned disc cam 138. A spring 157 attached to the bail 153 holds the follower 156 in engagement with the cam 138.

Two levers 158, only the forward one of which is shown, are pivotally mounted adjacent their left hand ends on pins 159 supported in posts 161 extending vertically from the mounting plate 36. Affixed to the forward lever 158 by screws 162 is an arm 163 in the free end of which is a cam follower 164 in operative relation with the top of the disc cam 138. A spring 166 attached to the lever 158 holds the follower 164 in engagement with the cam 138. Supported between the right hand ends of the levers 158 is a member 165 with a depending section 167. This depending member has in the lower end thereof a substantially horizontal pin 168. The pin 168 extends through a hole formed in an upwardly extending projection 169 of an angle member 170 fixed to the right hand ends of the operating pawls 151. The hole in the projection 169 is of sufficient size to permit free movement of the pin 168 therethrough.

As the cam 138 rotates in the direction indicated, the high part thereof first rocks the bail 153 in a clockwise direction and in doing so the points 149 of the pawls 151 engage the balls in the tube 128 and 131 and move them toward the right. After the pawls 151 are moved to their right hand positions the high part of the cam 138 engages the follower 164 to raise the right hand ends of the levers 158. The member 165 in rising with the right hand ends of the levers 158, through the instrumentalities of the depending section 167 and pin 168, raises the pawls 151 out of operative relation with the balls in the tubes. While the pawls are thus held in a raised position the cam 138 allows the bail 153 to rock in a counterclockwise direction and the levers 158 then allow the pawls to drop down and reengage the balls in the tubes 128 and 131. Thus on the return stroke of the pawls 151, they do not engage the balls and therefore do not have a tendency to move the balls in the wrong direction. Otherwise with only a few balls to the left of the pawls 151 the return movement thereof would be likely to move the few balls toward the left. As the balls are moved to the right by the operating pawls 151, the spring biased retaining pawls 146 prevent the weight of the balls in the substantial vertical sections, such as 171, Fig. 1, of the return tubes from moving the balls to the left. The sections 171, which are extensions of the tubes 128 and 131, convey the balls up to associated supply tubes 38 and 39, the balls dropping into their associated supply tubes when they reach the high point in the return tubes 171. Obviously the return tubes 171 are at all times full of their associated balls.

In brief review, the operation of the mechanism is as follows: The two sizes of balls in the supply tubes 38 and 39 are deposited or placed in the storage tubes 43 in accordance with the received signals. After being stored in the storage tubes 43 for a length of time depending upon various factors, the drum 84 rotates to remove a ball from each one of the tubes on each operation thereof and the balls actuate contacting elements in accordance with their size to set up on the stops 113 and 114 a code combination representative of the two sizes of the balls in a group. The balls are then separated into their respective size groups and the elevator mechanism 31 returns the same via the return tubes 171 to the supply tubes 38 and 39 where they are again selectable by the selector mechanism 33. Although the balls are separated into their respective groups prior to their return to the supply tubes, it is obvious that the separating operation could occur after they were elevated.

In the above paragraphs only the operation of the mechanical elements have been described and in the following paragraphs the manner in which various of these elements are controlled will be described, such as the manner in which the electric impulses of a code group are distributed to the selector magnets 41 and 42 of the selector mechanism and the manner in which the code combinations set up on the stops 113 and 114 are distributed to a sending circuit in timed relation with the operation or stepping of the

drum 84, Figs. 1 and 3. A mechanism will also be described in the following paragraphs which prevents the rotation of the drum 84 unless there are balls ready to be removed from the ends of the storage tubes 43, together with an alarm device operating in conjunction therewith. An auxiliary selector device is also described hereinafter which renders an alarm device operative whenever one of the units of the selector mechanism fails to deposit a ball in a storage tube for each cycle of operation thereof.

Referring now to Fig. 15 a description of the control circuits for the selection mechanism when associated with a machine such as a keyboard transmitter will now be given. The contacts of the keyboard mechanism represented in general as being within the dotted rectangle 172 comprises a set of five transmitting contacts 173 and a sixth contact 174. The contacts 173 by any one of several methods well known in the art are arranged to be sequentially or simultaneously closed in combinations representative of actuated keylevers and they may remain in closed or open position until the position thereof is changed by the actuation of a subsequent keylever. The sixth contact 174 however is normally open and adapted to be closed shortly after the operation of the contacts 173 in accordance with the actuated keylever, the contact 174 invariably closing momentarily on the actuation of each keylever. One side of the contacts 173 and 174 are all connected to battery. The other side or stop of the contact 174 is connected by conductor 176 through the coil of a so-called sixth pulse relay 177 to ground while the other sides or stops of the contacts 173 are connected by individual conductors 178 through the coils of associated neutral selecting relays 179 to ground. The tongues of the neutral selecting relays 179 are connected in parallel by a conductor 181 to the make-stop of the sixth pulse relay 177, the tongue 182 of which is connected to battery. The make stops of the neutral selecting relays 179 are connected by individual conductors 183 through the coils of associated marking selector magnets 41 to ground while the break stops of the relays 179 are connected by individual conductors 184 through the coils of the spacing selector magnets 42 to ground, the selector magnets 41 and 42 being similar to those shown in Figs. 1 and 11. The marking and spacing selecting magnets of a single selecting unit are those connected to the make and break stops respectively of one of the selecting relays 179. Also connected to the make-stop of the sixth pulse relay 177 by conductor 181 is the grounded coil of a control relay 186, the purpose and function of which will hereinafter be described.

When a keylever in the keyboard 172 is actuated, the contacts 173 are operated in accordance therewith which in turn cause the energization of the selector relays 179 associated with the closed contacts 173 and deenergization of the others to move their tongues to their make and break stops respectively. Shortly after the operation of the relays 179 in accordance with the condition of the contacts 173, the contact 174 in the keyboard closed to energize and cause the operation of the sixth pulse or relay 177. The operation of the relay 177 occurs while the selecting relays 179 are operated and applies battery to the tongues of the selector relays 179. Depending upon the condition of the selector relays 179 the battery at the tongues thereof is applied over conductors 183 and 184 to associated selector magnets 41 and 42. Thus, either one or the other of the selector magnets 41 and 42, but not both, of each selector unit is selectively operated in accordance with the closing of the contacts 173 in the control keyboard 172. One each of the selector magnets 41 and 42 are included in a selector unit and as either one or the other, but not both, of these magnets are operated for each cycle of operation either a marking or a spacing ball is deposited in associated storage tube. If there are five selector units, each having a marking and a spacing selector magnet such as 41 and 42, respectively, each of the associated five storage tubes 43, Fig. 2, will have either a marking or a spacing ball deposited therein on each cycle of operation of the keyboard. The control magnet 186 is operated on each cycle of operation by the sixth pulse relay 177 and is similar to one of the selector magnets 42. Associated with the control magnet 186 is substantially one-half of a selector unit, having one supply tube 39 and a control storage tube 187. The supply tube 39 associated with the magnet 186 has only one size of balls therein and accordingly each time it is operated one of these balls will be deposited in the control storage tube 187. These balls in the control supply tube 187 serve, as hereinafter described, to control the starting and stopping of the transmitting mechanism 32.

The control of the operation of the selector mechanism 33 will now be described when operated in response to and under the control of signals such as those received over a channel of a multiplex circuit, the associated circuits being shown in Fig. 16. A line relay 188 responsive to signals received over a line L has the marking and spacing stops thereof connected to opposite potentials and the tongue connected by conductor 189 to a solid ring 191 of a multiple ring distributor indicated generally by reference numeral 190. Segments numbered 1 to 5 of a ring 192 associated with a solid ring 191 are connected by individual conductors 193 through the coils of associated polar selecting relays 194 to ground. Thus, as the brush 196 bridges the rings 191 and 192, the selector relays 194 are operated in accordance with the position of the tongue of the relay 188 at the time the brush 196 contacts the segments of ring 192 connected to these relays. The selector relays 194 are adapted to operate in response to polar signals, the tongues moving in one direction in response to a positive signal impulse and in the opposite in response to a negative signal impulse. The marking and spacing stops of the selector relays 194 are connected by individual conductors 196 and 197, respectively, to the marking and spacing selector magnets 41 and 42 of the selector mechanism. Two local rings 198 and 199 of the distributor 190 have an associated brush 201 movable with the brush 196. Potential is supplied to the ring 198 and a segment 202 of the ring 199 is connected in parallel by a conductor 203 to the tongues of the selector relays 194 and the coil of the control magnet 186. Thus as brushes 196 and 201 traverse their associated rings, the selector relays 194 are first operated in accordance with the received signals and then the brush 201 contacts segment 202 to apply potential to the tongues thereof and the control magnet 186. Depending upon the position of the tongues of the relays 194 the potential from the segment 202 is applied to either the marking 41 or spacing 42 selector magnet of each associated selector

unit. Therefore either one or the other of the selector magnets will be operated for each cycle of the distributor and deposit either a marking or a spacing ball in the associated storage tube. Each time the brush 201 contacts the segment 202 control magnet 186 is operated to deposit a ball in the control storage tube 187 as herein before described.

In Fig. 17 the control circuits for the selector mechanism are shown when the selector is operated from a tape transmitter. For this arrangement the marking and spacing selector magnets 41 and 42 are controlled from the left and right hand stops respectively of polar selector relays 194, the same as in the last described arrangement of Fig. 16. The coils of the selector relays 194 are connected by individual conductors 204 to tongues of the controlling transmitter represented within the rectangle 206. The tongues of the tape transmitter, as well known in the art, are operated to contact either marking or spacing bus bars 207 and 208, respectively, in accordance with the perforations in the associated tape. A distributor indicated generally by reference number 210 for operating the transmitter comprises a solid ring 209 and a segmented ring 211 with an associated brush 212 adapted to bridge the two rings. The operating magnet 213 of the tape transmitter is connected to a segment 214 of the ring 211 and when the brush contacts this segment the tape transmitter is operated to advance the tape therein and operate the tongues in accordance with the perforations in the tape. As the tongues of the tape transmitter 206 are operated in accordance with a group of perforations in the associated tape, the selector relays 194 through the above described circuits are also selectively operated. Another segment 216 of the ring 211 is connected by conductor 217 to the tongues of the selector relays 194 and to the control magnet 186 and as the brush 212 contacts this segment 216, potential is applied to the tongues of the selector relays 194 and the control magnet 186. Thereupon the selector magnets 41 and 42 operate in accordance with the position of the tongues of their associated selector relays 194 in the same manner as the above described arrangements.

By an arrangement well known in the art, a cut-off relay may be associated with either of the circuits of Figs. 16 and 17 so that when code combinations cease to be received over the line L or the auto-control of the tape transmitter operates, the circuits to the selector relays 194 will be opened to prevent depositing of balls in the storage tubes during such conditions.

The circuits associated with the transmitting mechanism 32 will now be described, the transmitting mechanism as hereinbefore stated comprising the means for converting the various sizes of balls in the storage tubes 43 back into respective signaling impulses. The associated circuits control the operation of the transmitting mechanism and distributes the impulses of each code to a sending circuit. The balls which are deposited in the control storage tube 187, Figs. 1 and 18, and as hereinafter described control the start of the transmitting mechanism.

Supported from the vertical mounting plate 81 is a bracket 218 which has mounted thereon in a horizontal position a magnet 219, Figs. 1, 2 and 18. The magnet 219 has an associated armature 221 pivotally mounted adjacent its lower end and has operatively associated therewith adjacent its upper end a push rod or pin 222. Each time the magnet 219 is energized the armature 221 pivots in a counter-clockwise direction against the action of a retractile spring 224 to move the push pin 222 toward the left. The pin 222 is substantially horizontal and is guided adjacent its left hand end by a hole in a bracket 226 at the top of the member 87. The extreme left hand end of the rod 222 is in operative relation with a hole 227 formed in the side of the control storage tube 187 near the lower end thereof as shown in Fig. 4. When the armature 221 is in its unoperated position the left hand end of the pin 222 does not project into the inside of the control storage tube 187. However, each time the magnet 219 is energized the armature 221 attempts to move the left hand end of the rod 222 through the hole 227 in the tube 187 and into the inside of the tube. However, with the balls at the lower end of the tube 187 this movement of the pin 222 is blocked by the balls and hence the movement thereof is only a relatively small amount. Attached to the armature 221 adjacent the center thereof is a contacting element 228 which is adapted to make contact with a stop 229 when the rod 222 is allowed to enter an appreciable amount into the tube 187. However, in the normal position of the armature 221 and when the movement of the pin 222 is blocked by balls in the lower end of the control storage tube 187, the contacting element 228 and the stop 229 remain apart. The function of the magnet 219 in conjunction with the stepping of the drum 84 will now be described.

Assuming that there are no balls in the lower ends of any of the storage tubes 43 or the control storage tube 187 and that the brushes 231 and 232 of a distributor 233, Fig. 18, are continuously rotating. Associated with the brush 231 is a solid sending ring 234 which is connected to the sending line and is adapted to be bridged by the brush 231 with a segmented ring 236. The brush 232 bridges a solid ring 237 to which is connected positive potential with an associated segmented ring 238. The brushes 231 and 232 rotate together and as the latter contacts segment 239 of ring 238 an impulse of positive potential is applied over a conductor 241 through the coil 242 of a relay 243 and a shunting resistance 240 in shunt relation therewith, over a conductor 244 and then through the coil of the control magnet 219 to ground. This impulse causes the tongue of the relay 243 to move to its right hand contact and operates the magnet 219. The left and right hand stops of the relay 243 are connected to positive and negative potential, respectively, and as the tongue contacts the right hand stop negative potential is applied through the tongue over a conductor 246 to the bus bar 116 supporting the stops 113 associated with the contacting elements 112 on the transmitting levers 106. The upper bus bar 117, supporting the contacting elements 114, has positive potential connected thereto at all times. The contacting elements 112 on the transmitting levers 106 are connected by individual conductors 247 to segments numbered 1 to 5 of the ring 236. As it was assumed there were no balls in the control storage tube 187, the movement of the pin 222 is not blocked on the energization of the magnet 219 when the brush 232 contacts segment 239 and therefore the contacting element 228 on the armature 221 of the magnet is allowed to engage its make stop 229. This applies ground at the tongue 221 through the stop 229, over a con-

ductor 248, through a coil 249 of a relay 251 to positive potential. This circuit causes the tongue of the relay 251 to engage its right hand stop, the stop being connected by a conductor 252 through the coil 253 of relay 243 to ground. The left hand stop of the relay 251 is connected by a conductor 254 through the drum stepping magnet 98 to ground, the tongue being connected by a conductor 256 to a segment 257 of the ring 238.

With the tongue of the relay 251 on its right hand stop the circuit from the segment 257 to the drum stepping magnet 98 is open at the tongue of the relay 251. Therefore, as the brush 232 subsequently contacts segment 257 the impulse which otherwise would go to the magnet 98 is applied through the tongue and right hand stop of relay 251, over conductor 252 and through the coil 253 of relay 243 to ground, causing the tongue of said relay 243 to move to its left hand stop. This applies positive potential to the bus bar 116 and therefore, regardless of the positions of the contacting elements 112 on the transmitting levers which may still be operated in accordance with a group of balls, all the segments 1 to 5 on the ring 236 will have positive potential applied thereto. Now when the brush 231 subsequently contacts these segments, five impulses of positive potential will be transmitting over the line L. Thus a group of impulses is transmitted to the line representing an all-spacing combination when there are no balls in the control storage tube 187 to block the movement of the pin 222 and the drum stepping magnet 98 is not operated. About the time the brush 231 contacts the number one segment of the ring 236, the brush 232 contacts a segment 258 of ring 238 and applies positive potential over a conductor 259 through the coil 261 of relay 251 to ground. This impulse causes the tongue of the relay 251 to move to its left hand stop and completes a circuit from the segment 257 of the ring 238 to the drum stepping magnet 98. The above operations of the relays 243 and 251 and the magnet 219 continue for each revolution of the brushes 231 and 232 as long as there are no balls in the control storage tube 187 and during each revolution of the brushes an all-spacing group of impulses is transmitted to the line regardless of the conditions or positions of the transmitting levers 106.

A cycle of operation of the circuits of Fig. 18 will now be described in conjunction with the transmission of a group of impulses representative of a group of balls removed from the storage tubes 43. After two or three groups of balls appear at the lower ends of the storage tubes 43, balls will also appear at the lower end of the control storage tube 187, one ball being deposited therein in conjunction with each group of balls deposited in the storage tubes 43 as hereinbefore described. With three or four balls in the lower end of the control storage tube 187, the movement of the pin 222 into the tube is blocked. Thus when the brush 232 contacts the segment 239 of ring 238 the tongue of the relay 243 is operated to its right hand stop as above described, but the armature 221 does not make contact with its make stop 229 and hence the coil 249 of the relay 251 will not be energized. Now as the brush 232 contacts segment 257 an impulse of positive potential is applied over conductor 256 through the tongue and left hand stop of relay 251 over conductor 254 to the drum stepping magnet 98. This impulse operates the magnet 98, causing it to advance the drum and as hereinbefore described as the drum advances, a group of balls from the lower ends of the tubes 43 will be advanced into operative relation with the rollers 105, Fig. 3, on the right hand ends of the transmitting levers 106. The transmitting levers 106 are thereupon operated in accordance with the sizes of the balls so that the contacting elements 112 attached thereto are engaged with either the stops 113 or 114. At this time the bus bars 116 and 117 supporting the stops 113 and 114, respectively, have negative and positive potential, respectively, applied thereto, and positive and negative will be applied to the segments numbered 1 to 5 of ring 236 depending upon the settings of the transmitting levers 106, the settings of the transmitting levers 106 in turn being controlled by the sizes of balls in contact with the rollers 105 on the right hand ends of the transmitting levers. When the brush 231 subsequently contacts the segments 1 to 5 of the ring 236, a combination of impulse representative of the sizes of balls under the rollers 105 will be transmitted to the line. For the above set of conditions the tongue of relay 251 will be on its left hand stop and therefore as the brush 232 contacts segment 257, the position of the tongue of relay 251 is not changed.

Cycles of operation like the above continue with a code group of impulses being transmitted for each cycle representative of a group of balls removed from the storage tubes as long as the movement of the pin 222 by balls in the lower end of the control storage tube 187 is blocked. When all but two or three of the balls in the control storage tube 187 are removed, the pin 222 is allowed to enter the tube and when this condition occurs, the transmitter functions to transmit a code group of all-spacing impulses as hereinabove pointed out. Two or three extra balls may be placed in the control tube 187 prior to the start of the mechanism to enable all the balls to be removed from the storage tubes 43 before the movement of the pin 222 is blocked.

Thus when there are no balls in the lower ends of the storage tubes 43 or but the two or three extra ones in the control tube 187, an all-spacing group of impulses is transmitted to the line on revolutions of the brushes 231 and 232. However, when balls do appear in the storage tubes, the drum 84 is rotated to remove the balls and transmit a group of impulses representative of their size, these groups of impulses continuing as long as the movement of the pin 222 into the control tube 187 is blocked.

In Fig. 18 it was assumed that the brushes 231 and 232 were constantly rotating and that multiplex type signals were transmitted. However, with obvious changes simplex type signals could be transmitted by the transmitting mechanism to represent the different sizes of balls removed from the storage tubes.

Referring to Figs. 12 and 19 a description of a modification of a selector unit, together with the control and operating circuits will now be given. In this modification the marking and spacing balls are supplied to each unit of the selector by the supply tubes 38 and 39 as in the above described selector, a ball being removed from either one or the other of the supply tubes and deposited in the storage tube 43 on each operation of the unit. The supply tubes 38 and 39 are substantially vertical at the selector unit and the arms of the Y of the associated storage tube 43 are substantially horizontal where they join the associated supply tubes. The lower ends of

the supply tubes and the Y at the upper ends of the storage tubes are held in position by longitudinal members such as 262 and 263 bolted to the underside of the mounting plate 34. With balls in the supply tubes 38 and 39 the lowermost one rests upon the upper horizontal section of the Y at the upper end of the associated storage tube 43. These balls are prevented from rolling into the supply tube 43 by bell cranks 264, the horizontal arms of which form detents to hold the balls in the ends of associated supply tubes. Each of the supply tubes have an associated bell crank such as 264 which are pivotally mounted at 266. Individual springs such as 267 associated with the bell cranks 264 bias the same to normal positions. On opposite sides of the longitudinal members 262 and 263 are plates 268 which have a series of holes therein in alignment with the supply tubes 38 and 39. These holes are opposite the ball at the lower end of the supply tubes and form guides for associated longitudinal plungers 271 adjacent their inner ends. The plungers or push rods 271 are connected at their outer ends to the upper ends of associated armatures 272. The armatures 272 are operated by the energization of their associated marking and spacing selector magnets 41' and 42' respectively, and retractile springs 273 normally maintain the armatures in their retracted positions.

When either one of the selector magnets 41' or 42' is operated the inner end of the associated push rod 271 engages the ball at the lower end of the supply tube to push it over the bell crank detent 264 and into the storage tube 43. As the ball passes the bell crank detent 264 the depending arm thereof actuates one of the springs of an associated normally open contact 274 to close the same. The manner in which the contacts 274 functions to render the alarm device inoperative whenever the ball is deposited in the storage tube 43 will hereinafter be described.

The selector magnets 41' and 42' may be operated in accordance with any of the methods hereinbefore described such as from a keyboard, tape transmitter or a line relay. If for some reason one of the plungers 271 fails to move the ball over the associated detent the contact 274 would not be closed and as pointed out in the following paragraphs such a condition would render an alarm device operative.

The circuits for one unit of the alarm device and for one unit of the associated selector mechanism are shown in Fig. 19 where the selector unit is shown controlled from a tape transmitter in much the same way as that shown in Fig. 17. As only one unit of the selector mechanism is shown for the purpose of simplicity of the drawings, only one of the tongues of the transmitter 206 is shown connected to one of the associated selector relays 194, the other tongues of the transmitter being connected in a similar manner to other selector relays 194 which in turn control other selector units. A distributor 276, Fig. 19, is employed to operate the tape transmitter 206 and time the operations of the associated selector unit. The distributor has a brush 277 adapted to bridge a solid ring 278 with various segments of a segmented ring 279. Positive potential is normally applied to the solid ring 278 from the tongue of a normally deenergized double coil relay 282 over the associated brake-stop, a conductor 283, through the tongue and brake-stop of a second normally deenergized double coil relay 284 and thence over a conductor 286 to the solid ring 278. Thus the ring 278 normally has potential applied thereto and when the brush 277 contacts segment 287 of ring 279 positive potential is applied over a conductor 288 to operate the stepping magnet 289 of the tape transmitter 206. The tongues of the tape transmitter being operated in accordance with the perforations in the tape, apply positive and negative potential over conductors such as 291, to associated polar selector relays 194 only one of which is shown, to operate the same in accordance with the operation of the tongues of the transmitter. The tongues of the selector relays 194 are connected by a conductor 292 to a segment 293 of the ring 279 and when the brush 277 subsequently contacts this segment positive potential is applied to the tongues of the selector relays 194. The marking and spacing selector magnets 41' and 42' of each unit are connected by associated conductors 294 and 296 to the left and right hand stops respectively of the selector relay 194. Therefore depending upon the position of the tongue of the selector relay 194 at the time the brush 277 contacts segment 293 either one or the other of the selector magnets 41' or 42' will be energized. Battery is applied to one of the springs of each of the contacts 274 and the other springs of these contacts are connected by conductors 297 and 298 through the coils 299 and 301 respectively of relays 302 and 303 respectively. A resistance 304 is connected between the conductors 296 and 297 while a similar resistance 306 is connected between the conductors 294 and 298. The purposes of the resistances will hereinafter be pointed out. Let it be assumed for example that the tongue of the selector relay 194 is on its right hand stop and the brush 277 contacts segment 293 to operate the selector magnet 42' to cause the transfer of a ball from the supply tube 39 into the storage tube 43. Part of the current from the right hand stop of the selector relay 194 passes through the resistance 304 and coil 299 of relay 302 to move the tongue thereof to its left hand stop. As the ball is transferred from the supply tube 39 the associated detent bell crank 264 is momentarily operated to close the contact 274 which applies potential over conductor 298 through the coil 301 of relay 303 to operate the tongue thereof to its right hand stop. The resistance 306 connected between the conductors 298 and 294 is of such a value as to prevent enough current to flow through the selector magnet 41' to operate the same when the contact 274 at selector magnet 42' is closed. Therefore, this magnet 41' will not be operated. The right hand stop of the relay 302 is connected over a conductor 307 through the right hand coil of relay 282, conductor 313, to a segment 311 of ring 279 to which is also connected the left hand stop of relay 303 by a conductor 312 through the left hand coil of relay 284. With the tongues of relays 302 and 303 on the left and right hand stops respectively the above circuits are open at the stops and therefore when the brush 277 contacts the segment 311 for the above set of conditions, neither of the relays 282 or 284 will be operated. Accordingly the circuits for an alarm device hereinafter described which is rendered operative on the energization of either one of the relays 282 or 284 is not operated. Sometime after the brush 277 leaves the segment 311 it contacts a segment 309 and applies an impulse of positive potential over a conductor 310 to coils 315 and 315' of relays 302 and 303 respectively. This im-

pulse causes the tongues of relays 302 and 303 to move to their normal positions, i. e. their right and left hand stops respectively. The circuits are thereupon all back to their normal condition and as long as a ball from one of the supply tubes 38 or 39 is deposited in the storage tube 43 for each cycle of operation of the transmitter 206 the alarm devices remain unoperative, it being apparent from a study of the circuits that the relays 282 and 284 will remain unoperated as in the above described cycle of operation, when a ball is removed from the supply tube 38 on the energization of the selector magnet 41'.

Now let it be assumed that for some reason the selector magnet 42' failed to remove a ball from the supply tube 39 on the operation thereof. For this cycle the associated contact 274 will not be operated and therefore the grounded tongue of the relay 303 will remain on its left hand stop. With the tongue of the relay 303 in this position a circuit will be completed through the left hand coil of relay 284 when the brush 277 subsequently contacts segment 311, resulting in the operation of relay 284. The relay 284 in operating locks up through its right hand coil and supplies potential through an individual alarm device such as a lamp 314, a key 316 and a second common alarm device such as an audible alarm 317 to ground. The operation of the relay 284 also breaks the circuit of the positive potential to the solid ring 278 and therefore during following revolutions of the brush 277 the transmitter 206 or none of the selecting magnets 41' or 42' are operated. The operation of the alarm device 317 calls the attention of attendant while the lamp 314 indicates which one of the selector magnets such as 42' failed to deposit a ball in the storage tube 43. The attendant thereupon operates the key 316 which may also deposit the missing ball in the storage tube and restores the above described circuits to normal. Similarly, the failure of the selector magnet 41' to function properly will render the individual alarm lamp 318 and the common alarm device 317 operative. The alarm device 317 may also be common to other sets of the alarm lamps, two for each selector unit such as 314 and 318 which indicate which half of a particular selector unit failed to function properly. Thus whenever a ball is not deposited in the storage tube 43 further operation of the selector mechanism is stopped until this condition is corrected and on the correction of this condition which may be automatically controlled by a key such as 316 the selector mechanism resumes operation.

Although this alarm circuit is shown in conjunction with the modification of a selector unit, it will be apparent to those skilled in the art that it could be readily applied to a selector unit such as shown in Fig. 11.

The apparatus and circuits whereby an alarm device is rendered operative whenever a ball is not removed from each one of the storage tubes 43 on each movement of the drum 84 will now be described. If such condition is not made known immediately or soon after it occurs the drum 84 may continue to step and remove groups of balls from the storage tubes and it is obvious whenever a ball is not removed from one or more of the storage tubes while others have balls removed therefrom each succeeding group of balls removed from the storage tubes will not represent a code group as received on the selector mechanism. When a ball is not removed from the storage tube on the stepping of the drum 84 the associated transmitting lever 106 will operate in the same manner as if a small ball was in the associated pocket. Hence it is necessary when the transmitter drum 84 fails to remove a ball from the storage tube to call this condition to the attention of an operator and preferably stop further movement of the drum. It is also desirable to indicate which one of the storage tubes has an extra ball therein so that a lowermost ball may be removed whereafter the groups of balls in the tubes will represent groups as selected by the selector mechanism.

Referring to Fig. 13 a set of auxiliary levers such as 319 are pivotly mounted adjacent their centers at 321 on a supporter 322 which in turn is supported from the members 108. There is an auxiliary lever 319 for each peripheral row of pockets in the drum 84 and the depending arms 323 at the right hand ends thereof are in alignment with an axial row of pockets on the drum 84. The row of pockets with which the arms 323 are in alignment with in the stop position of the drum 84 being as close as possible, preferably the next or preceding the row in alignment with the rollers 105 on the ends of the transmitting arms 106. Springs 324 attached to the levers 319 tend to pivot them in a clockwise direction and force the arms 323 into the pockets 86 in the drum 84. However with a ball in the pocket the movement of the arm into the pocket is blocked. The left hand end of each of the levers 319 carry insulating pieces 326 which are in engagement with one of the springs of a normal open contact 327. Whenever the arm 323 on any one of the levers 319 is held out of the pockets 86 in the drum 84 the associated contact 327 remains in an open position. However, if a pocket 86 happens to not have a ball therein when brought beneath the ends of any one of the arms 323 the attached spring 324 is allowed to pivot the associated lever 319 and close its associated contact 327. The manner in which the closing of such a contact renders an alarm device operative and stops further rotation of the drum 84 will now be described the circuits therefor being shown in Fig. 20.

Although in Fig. 20 only one contact such as 327 and associated elements are shown it is obvious that each of the peripherial rows of the pockets in drum 84 may have an associated auxiliary lever 319 and contact 327 to operate an alarm device as will now be described. A relay 328 has the tongue thereof normally biased to its left hand stop by a comparatively weak biasing current in a coil 329, the tongue being grounded through a key 332. This left hand stop of the relay 328 is connected by a conductor 331 to one side of the coil of the drum stepping magnet 98 the other side of which is connected to segment 257 of ring 238 through the left hand stop and tongue to the relay 251 in the same manner as shown in Fig. 18. The magnet 98 in Fig. 20 is adapted to be operated in the same manner as in Fig. 18 the only change being that the ground circuit for the magnet is through the left hand stop and tongue of relay 328 and key 332. This circuit obviously being opened when the tongue of relay 328 is on its right hand stop.

As long as the contact 327 remains in an open condition the tongue of the associated relay 328 remains on its left hand stop as held by the effect of the biasing coil 329 and the drum 84 will be stepped each time an impulse of current is received over the conductor 254. If however the contact 327 should happen to close due to the absence of a ball in any one of the pockets 86

of the drum 84, a circuit is completed from ground at one of the elements of the contact 327, through the contact 327, over a conductor 327', through a coil 333 of relay 328, over a conductor 330 and through a coin 330' of relay 251 to positive potential. The above circuit causes the tongues of the relays 328 and 251 to move to their right hand stops. The effect of the coil 333 of relay 328 is sufficient to overcome the biasing effect of the coil 329 tending to move the tongue of the relay to its left hand stop. Similarly, the effect of the coil 330' of relay 251 is sufficient to maintain the tongue on its right hand stop and overcome the effect of coil 261 which tends to move the tongue of the relay to its left hand stop when its operating circuit is subsequently completed by the brush 232 contacting segment 258. Hence the tongues of the relays 328 and 251 remain on their right hand stops as long as the contact 327 remains closed. With the tongue of the relay 328 on its right hand stop an additional locking circuit is provided therefor from battery through a coil 334 of the relay 328 over a conductor 335, through an alarm device such as a signal lamp 336 and the right hand stop and tongue to the grounded key 332. With the tongue of the relay 328 on its right hand stop the circuit to the drum stepping magnet 98 is opened thereat and further drum stepping impulses from segment 257 of ring 238 will not be effective to step the drum 84. With the tongue of the relay 251 held on its right hand stop the relay 243 will be operated as in the above described arrangement in connection with Fig. 18 to cause positive potential to be applied to both of the bus bars 117 and 116 of the transmitting mechanism. Hence for each succeeding revolution of the brushes 231 and 232, a group of impulses of the same polarity will be transmitted to the line. Thus, sensing means comprising contacts such as 327 is arranged to stop further rotation of the drum 84 when one or more of the pockets therein fail to remove a ball or balls from one or more of the storage tubes 43 and at the same cause the transmission of an all spacing signal in the same manner as when the rotation of the drum is stopped by virtue of there being no balls to block the movement of the plunger 222 in the control tube 187. In Fig. 20 the relay 251 is shown with an extra coil 330', the other circuits of the relay 251 being identical with those shown in Fig. 18.

The completion of the circuit through the alarm device 336, as above described, causes the operation thereof which indicates which one of the storage tubes 43 failed to have a ball removed therefrom on a preceding movement of the drum 84. The attendant in correcting this condition by removing a ball from the proper storage tube 43 and placing it under the lever 319 also operates the key 332 to open the locking circuits through the coils 334, 333 and 330' of the relays 328 and 251, permitting return of the circuits to normal. An audible alarm may be connected by obvious circuits well known in the art to operate whenever any one of the signal lamps 336 operates to attract the attention of the operator, while individual lamps such as 336 indicate the particular tube or tubes from which balls were not removed.

It is obvious that the alarm device shown in Fig. 20 and the control device of Fig. 18 operate independently of one another and each function independently to stop further movement of the drum when the conditions are such as described.

The selector mechanism 33 Fig. 1 may be an appreciable distance from and directly above the transmitting mechanism 32. Where such a condition exists and the storage tubes 43 connecting the transmitting mechanism with the selecting mechanism are comparatively straight the balls may drop down the tubes, hit the drum 86 and bounce an appreciable distance back up the tubes 43. If the movement of the plunger 222 into the control tube 187 happen to be blocked while these balls were bouncing up and down in the storage tubes 43, the drum 84 might be stepped without each of the pockets having a ball therein. Although the alarm device described in Fig. 20 would indicate such a condition after one or two movements of the drum 84 such a condition would cause more or less delay in the transmission of succeeding groups of impulses. To overcome the disadvantage of having balls bounce up and down in the storage tubes 43 the lower ends thereof preferably have a series of one or more slight bends therein as shown in Fig. 14. These bends prevent the balls from bouncing appreciably and also serve to slow the movement of the balls down as they approach the drum 84. The control tube 187 may have a series of bends therein the same as the storage tubes 42 and several such bends may be employed instead of a curved control storage tube to delay the movement of the balls therein. The control storage tube 187 preferably having a greater number of such bends than the storage tubes 43 to insure that the balls in the storage tubes will be at the ends thereof before those in the control tube.

Although in the above described arrangements five selecting units, five storage tubes and five transmitting units were employed, one for each impulse of a five unit signaling code, it will be obvious that the number of units could be varied for codes with a different number of units. Also with minor circuit changes one selecting unit, one storage tube and one transmitting unit could be employed instead of the five as described, each of the units then being operated for each unit of the signaling code and the consecutive balls in the storage representing the consecutive units of the signaling code.

It is obvious, of course, that various other modifications of the invention may be made to accomplish similar results without departing from the spirit or the essential attributes thereof and is desired, therefore, that only such limitations be placed thereon as are imposed by the prior art or are specifically set forth in the appended claims.

What is claimed is:

1. In a signal storage telegraph machine, a plurality of two different types of mechanical elements, a plurality of conveying and storage means for said mechanical elements adapted to confine and store said elements in the order in which selected, means for removing a mechanical element from each of said conveying and storage means on each cycle of operation of said telegraph machine, a detecting means, means controlled by said detecting means for preventing further cycles of operation of said removing means on the failure thereof to remove a mechanical element from each of said conveying and storage means and means for indicating from which one or ones of said conveying and storage means said removing means failed to remove a mechanical element on a cycle operation thereof.

2. In a signal storage telegraph machine for transmitting code groups of impulses of two different line conditions, a plurality of balls of two different sizes arranged in a plurality of files with consecutive ones of the two different sizes of balls in the first, second, third, etc., files representing the two different line conditions of the first, second, third, etc., impulses of the consecutive code groups to be transmitted, cyclically operable means for removing a group of balls comprising one from each of said files at a time and transmitting a representative code group, detecting means for detecting the failure of said last mentioned means to remove a ball from each of said files, means controlled by said detecting means for stopping further operation of said removing means on the failure thereof to remove a ball from each one of said files on each cycle of operation thereof and means for indicating the file or files from which said removing means failed to remove a ball that caused the stopping thereof.

3. In a storage transmitter, a plurality of two different sizes of current controlling members, permutation means for selecting said two different sizes of members in various permutations, storage means for storing said permutations of members in selected order, transmitting contacts, a rotatable drum and means including said rotatable drum for removing said members from said storage means and moving the same in the order selected past said transmitting contacts whereby the members operate said contacts in accordance with the sizes thereof to one or the other of two positions.

4. In a storage transmitter, a plurality of two different sizes of current controlling members, permutation means for selecting said two different sizes of members in various permutations, storage means for storing said permutations of members in selected order, transmitting contacts, a rotatable drum with pockets therein, means for rotating said drum past said storage means, means operative on such movement of said drum and including the pockets therein to remove contact controlling members from said storage means, one member individual to each pocket, and in the order selected, means including said drum for then moving said members past said transmitting contacts and means controlled by said members in said pockets of said drum for operating said contacts in accordance with the sizes of said members to either one or the other of two operated positions.

5. In a storage transmitter, a plurality of two different sizes of current controlling members, permutation means for selecting said two different sizes of members in various permutations, storage means for storing said permutations of members in selected order, transmitting contacts, a rotatable drum with pockets therein, means for rotating said drum past said storage means, means operative on such movement of said drum and including the pockets therein to receive contact controlling members from said storage means, one member individual to each pocket, and in the order selected, means including said drum for then moving said members past said transmitting contacts, means controlled by said members in said pockets of said drum for operating said contacts in accordance with the sizes of said members to either one or the other of two operated positions, and means for stopping rotation of said drum on the failure of a pocket therein to receive a contact controlling member on movement thereof past said storage means.

6. In a telegraph signal storage transmitter, a plurality of two different sizes of contact controlling members, signal control means for selecting permutations of said contact controlling members in accordance with the operation thereof, a plurality of storage means for storing said contact controlling members, a set of transmitting contacts, a rotatable drum having a plurality of recesses therein, means including a magnet for rotating said drum to move said recesses relative to said storage means and said transmitting contacts, means operative on the movement of said recesses relative to said storage means to receive a contact controlling member from each of said storage means and moves the same relative to said transmitting contacts to control the operation thereof, and means operative on the failure of one or more of said recesses to receive a contact controlling member from one or more of said storing means to render said magnet inoperative.

7. In a storage transmitter, a plurality of two different sizes of mechanical elements, signal controlled means for selecting permutations of said mechanical elements in accordance with the operation thereof, storage means for storing selected permutations of said mechanical elements, a transmitting mechanism, a rotatable drum, a first means including said drum for removing permutations of said mechanical elements from said storage means and a second means including said drum for controlling said transmitting mechanism in accordance with the size of said mechanical elements removed by said drum from said storage means.

8. In a storage transmitter, a plurality of two different sizes of mechanical elements, signal controlled means for selecting permutations of said two different sizes of mechanical elements, storage means for storing permutations of said two sizes of mechanical elements in the order selected, a transmitting mechanism for removing the selected permutations of said two sizes of mechanical elements from said storage means and transmitting representative code groups of signals, sensing means for sensing the presence of said two sizes of mechanical elements in said storage means and means controlled by said sensing means for controlling the operation of said transmitting mechanism.

9. In a storage transmitter, a plurality of two different sizes of mechanical elements, signal controlled means for selecting permutations of said mechanical elements, storage means for storing permutations of said mechanical elements in the order selected, a transmitting mechanism for removing the selected permutations of said mechanical elements from said storage means and transmitting representative code groups of signals, a first sensing means associated with said storage means to sense the presence of mechanical elements in said storage means, means controlled by said first sensing means to initiate the operation of said transmitting mechanism, a second sensing means for sensing complete permutations of mechanical elements in said transmitting mechanism, means controlled by either of said first or second sensing means for stopping operation of said transmitting mechanism and means for transmitting code groups of predetermined type on the stopping of said transmitting mechanism by either of said sensing means.

10. In a storage transmitter, a plurality of two different sizes of mechanical elements, a plurality

of storage means having entrances and exits for said mechanical elements, means for selecting permutations of said elements and depositing the same in the entrances of said storage means, one element of each permutation to a storage means, a transmitting mechanism for removing permutations of said elements from said storage means in the order selected and transmitting representative code groups, sensing means for sensing the presence of permutations of said mechanical elements at the exits of said storage means, means controlled by said sensing means for releasing said transmitting means for operation on the presence of said mechanical elements at the exits of said storage means and means for preventing the operation of said transmitting means on the absence of mechanical elements at the exits of said storage means.

11. In a storage transmitter, a plurality of two different sizes of mechanical elements, a plurality of storage means having entrances and exits for said mechanical elements, means for selecting permutations of said mechanical elements and depositing the same in the entrances of said storage means, one element of each permutation to a storage means, means of gravity for moving said mecahnical elements from said entrances to said exits in said storage means, a transmitting mechanism for removing permutations of said elements from said storage means in the order selected and transmitting representative code groups, sensing means associated with one of said storage means to sense the presence of said mechanical elements at the exit thereof, means controlled by said sensing means for controlling the operation of said transmitting means and means to delay the movement of mechanical elements from the entrance to the exit of the storage means associated with said sensing means to insure the presence of mechanical elements at the exits of the others of said storage means on the sensing of a mechanical element in the storage means associated with said sensing means.

12. In a signal storage telegraph machine, a plurality of balls of one size, a plurality of balls of another size, a plurality of pairs of supply tubes for confining said two sizes of balls, one tube of each pair confining one size of said balls and the other tube of each pair confining the other size of said balls, a storage tube associated with each of said pair of supply tubes, a pair of independently operable electro-magnetic means associated with each of said pair of supply tubes, a source of telegraph signals comprising permutation groups of impulses of two different line conditions, the number of line conditions of each group being equal to the number of pairs of electro-magnetic means, means for distributing each group of impulses to said electro-magnetic means whereby one or the other of each group receive an impulse in accordance with the line condition, means for operating said electro-magnetic means and means to remove a ball from an associated one of said supply tubes and deposit the same in said storage tubes.

13. In a machine of the character described, a plurality of storage tubes for confining two different sizes of mechanical elements in the order in which the same are deposited therein, a rotatable drum having a series of axial rows of pockets therein, said pockets being movable beneath said storage tubes to remove balls therefrom, an alarm device, means operative on the failure of said drum to remove a ball from said storage tubes to render said alarm device operative and means for stopping further movement of said drum on the operation of said alarm device.

14. In a storing transmitter, a plurality of mechanical selecting elements, selecting means for selecting permutations of said mechanical elements, transmitting means, storage means for storing selected permutations of said mechanical elements and conveying the same by gravity to said transmitting means, abrupt bends in said storage means, and means including said abrupt bends in said storage means for changing the direction of movement of said elements to retard the speed thereof in said storage means as they approach said transmitting means.

15. In a storing transmitter, a plurality of mechanical selecting elements, selecting means for selecting permutations of said mechanical elements, transmitting means, storage means for storing selected permutations of said mechanical elements and conveying the same by gravity to said transmitting means, a series of bends in said storage means and means including said bends in said storage means for preventing appreciable bouncing or return movement of said mechanical elements in said storage means on approaching said transmitting means.

16. In combination, a tape transmitter having a set of contacts, means for operating said contacts in accordance with perforations in an associated tape, a plurality of two different sizes of mechanical elements, storing means for storing said elements and selecting means controlled by said contacts for selecting permutations of said mechanical elements and depositing the same in said storing means in accordance with the operation of said transmitting contacts.

17. In combination, a keyboard having a set of contacts, means controlled by said key levers for operating said contacts to various combinations according to actuated keylevers, a plurality af two different sizes of mechanical elements, storing means for said mechanical elements and selecting means controlled by said contacts for selecting permutations of said mechanical elements and depositing the same in said storing means in accordance with the operation of said contacts.

18. In combination, a plurality of two different sizes of mechanical elements, storing means for storing selected permutations of said elements, a tape transmitter, selecting means controlled by said tape transmitter for selecting permutations of said mechanical elements and depositing the same in said storing means, a detecting means, means including said detecting means for detecting the failure of said selecting means to deposit a complete permutation of said mechanical elements in said storing means and means for stopping further operation of said tape transmitter on the detection of other than a complete permutation of said mechanical elements by said detecting means.

19. In a storing transmitter, a plurality of two different sizes of mechanical elements, means for selecting permutations of said mechanical elements, a plurality of storage means for storing selected permutations of said elements, one element of each permutation to a storage means, a detecting means for detecting permutations of said elements in said storage means as selected by said selecting means and means controlled by said detecting means for stopping further operation of said selecting means on the failure thereof

to deposit an element of a permutation in each of said storage means.

20. In a storing transmitter, a plurality of two different sizes of mechanical elements, means for selecting permutations of said mechanical elements, a plurality of storage means for storing selected permutations of said elements, one element of each permutation to a storage means, a detecting means for detecting permutations of said elements in said storage means as selected by said selecting means, means controlled by said detecting means for stopping further operation of said selecting means on the failure thereof to deposit an element of a permutation in each of said storage means, and means for indicating which one of said storage means said selecting means failed to deposit an element therein.

21. In a storing transmitter, a plurality of two different sizes of mechanical elements, means for selecting permutations of said mechanical elements, a plurality of storage means for storing selected permutations of said elements, one element of each permutation to a storage means, a detecting means for detecting permutations of said elements in said storage means as selected by said selecting means, means controlled by said detecting means for stopping further operation of said selecting means on the failure thereof to deposit an element of a permutation in each of said storage means, and means for indicating which one of said storage means said selecting means failed to deposit an element therein and the size of the element which should have been deposited therein.

22. In a storage transmitter, a plurality of two different sizes of balls, pairs of supply tubes, one of each pair for each size of balls for conveying the same by gravity to said transmitter, storage tubes, one for each pair of supply tubes located therebeneath and adapted to receive both sizes of balls and maintain them in order, shuttles associated with each of said supply tubes and interposed between said supply tubes and said storage tubes, means for selectively operating said shuttles, and means including said shuttles on the operation thereof to initiate the movement of a ball into said storage tubes.

23. In a storage transmitter, a plurality of two different sizes of balls, pairs of supply tubes, one of each pair for each size of balls for conveying the same by gravity to said transmitter, storage tubes, one for each pair of supply tubes located therebeneath and adapted to receive both sizes of balls and maintain them in order, shuttles associated with each of said supply tubes and interposed between said supply tubes and said storage tubes and adapted to be operated in a direction substantially perpendicular to the direction of movement of said balls in moving from said supply tubes to said storage tubes, means for selectively operating said shuttles to deposit permutations of said balls in said storage tubes, and means operated by said shuttles for accelerating the movement of said balls from said supply tubes to said storage tubes on the operation of said shuttles.

24. In a ball storage transmitter, a plurality of two different sizes of balls, a plurality of pairs of supply tubes, one of each pair for each size of balls for conveying the same by gravity to said transmitter, a plurality of storage tubes one for each pair of supply tubes, magnets associated with each of said supply tubes, means operated by said magnets for removing balls from associated supply tubes and depositing in the associated storage tube, means for selecting one or the other of the magnets associated with each pair of supply tubes for operation on each cycle of operation of said transmitter, alarm devices associated with each of said supply tubes, means controlled by a ball removed from a supply tube of a pair for maintaining the alarm device associated with said pair of tubes inoperative, and means for operating the alarm device associated with the supply tube from which a ball failed to be removed therefrom on the operation of the associated magnet.

25. In a signal storage telegraph machine for transmitting code groups of impulses of two different line conditions, a plurality of balls of two different sizes arranged in a plurality of files with consecutive ones of the two different sizes of balls in the first, second, third, etc., files representing the two different line conditions of the first, second, third, etc., impulses of the consecutive code groups to be transmitted, cyclically operable means for removing a group of balls comprising one from each of said files at a time and transmitting a representative code group, detecting means for detecting the failure of said last mentioned means to remove a ball from each of said files, means controlled by said detecting means for stopping further operation of said removing means on the failure thereof to remove a ball from each of said files on each cycle of operation thereof, means for indicating the file or files from which said removing means failed to remove a ball that caused the stopping thereof and means for transmitting code groups composed of one line condition on the stopping of said ball removing means.

26. In a storage transmitter, a plurality of two different sizes of mechanical elements, signal controlled means for selecting permutations of said mechanical elements, storage means for storing permutations of said mechanical elements in the order selected, a transmitting mechanism for removing the selected permutations of said mechanical elements from said storage means and transmitting representative code groups of signals, a first sensing means associated with said storage means to sense the presence of mechanical elements in said storage means, means controlled by said first sensing means to initiate the operation of said transmitting mechanism, a second sensing means for sensing complete permutations of mechanical elements in said transmitting mechanism and means controlled by either of said first or second sensing means for stopping operation of said transmitting mechanism.

27. In combination, a plurality of two different sizes of mechanical elements, storage means for storing selected permutations of said elements, a tape transmitter, selecting means controlled by said tape transmitter for selecting permutations of said mechanical elements and depositing the same in said storage means, a normally inoperative alarm device, a detecting means and means including said detecting means for detecting the failure of said selecting means to deposit complete permutations of said mechanical elements in said storing means and means for rendering said alarm device operative and stopping further operation of said tape transmitter on the detection of other than a complete permutation of said mechanical elements by said detecting means.

28. In a ball storage transmitter, a plurality of

two different sizes of balls, a plurality of pairs of supply tubes, one of each pair for each size of balls for conveying the same by gravity to said transmitter, a plurality of storage tubes one for each pair of supply tubes, selectively operable means for removing permutations of said balls from said supply tubes and depositing the same in said storage tubes, a normally inoperative alarm device, and means controlled by the complete permutations of said balls removed from said supply tubes for maintaining said alarm device inoperative.

29. In a storage transmitter, a plurality of two different sizes of mechanical elements, signal controlled means for selecting permutations of said two different sizes of mechanical elements, storage means for storing permutations of said two sizes of mechanical elements in the order selected, said storage means having entrance and exit points for said mechanical elements, a transmitting mechanism for removing selected permutations of said two sizes of mechanical elements from said storage means and transmitting representative code groups of signals, sensing means for sensing the presence of said two sizes of mechanical elements in said storage means and means controlled by said sensing means for releasing said transmitting means to remove permutations of said mechanical elements from said storage means and transmit representative code groups of signals.

30. In a storage transmitter, a plurality of two different sizes of balls, pairs of supply tubes, one of each pair for each size of balls for conveying the same by gravity to said transmitter, storage tubes, one for each pair of supply tubes located therebeneath and adapted to receive both sizes of balls and maintain them in order, shuttles associated with each of said supply tubes and interposed between said supply tubes and said storage tubes and adapted to be operated in a direction substantially perpendicular to the direction of movement of said balls in moving from said supply tubes to said storage tubes, means for selectively operating said shuttles to deposit permutations of said balls in said storage tubes, said shuttles having surfaces sloped relative to the direction of movement thereof for accelerating the movement of said balls from said supply tubes to said storage tubes on the operation of said shuttles.

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