March 10, 1964 E. K. MENTZER ETAL 3,124,355

AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 1

Fig. 1.

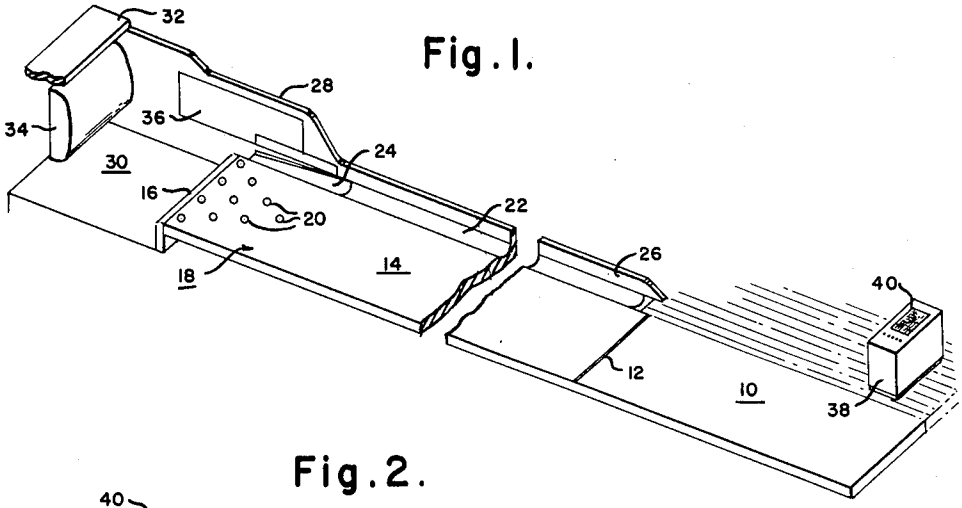


Fig. 2.

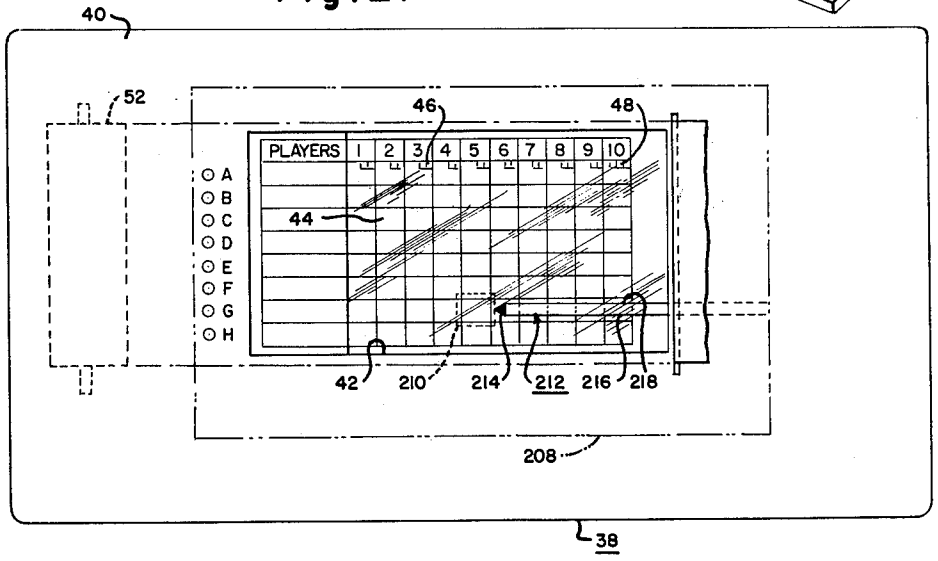
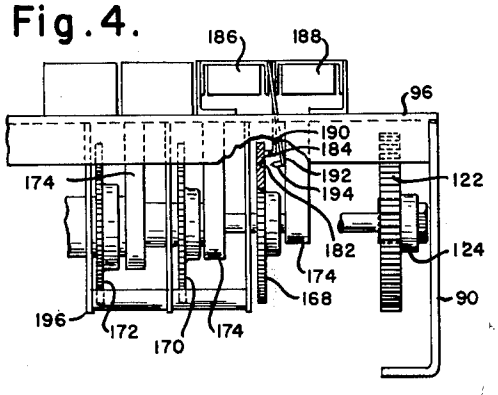


Fig. 4.



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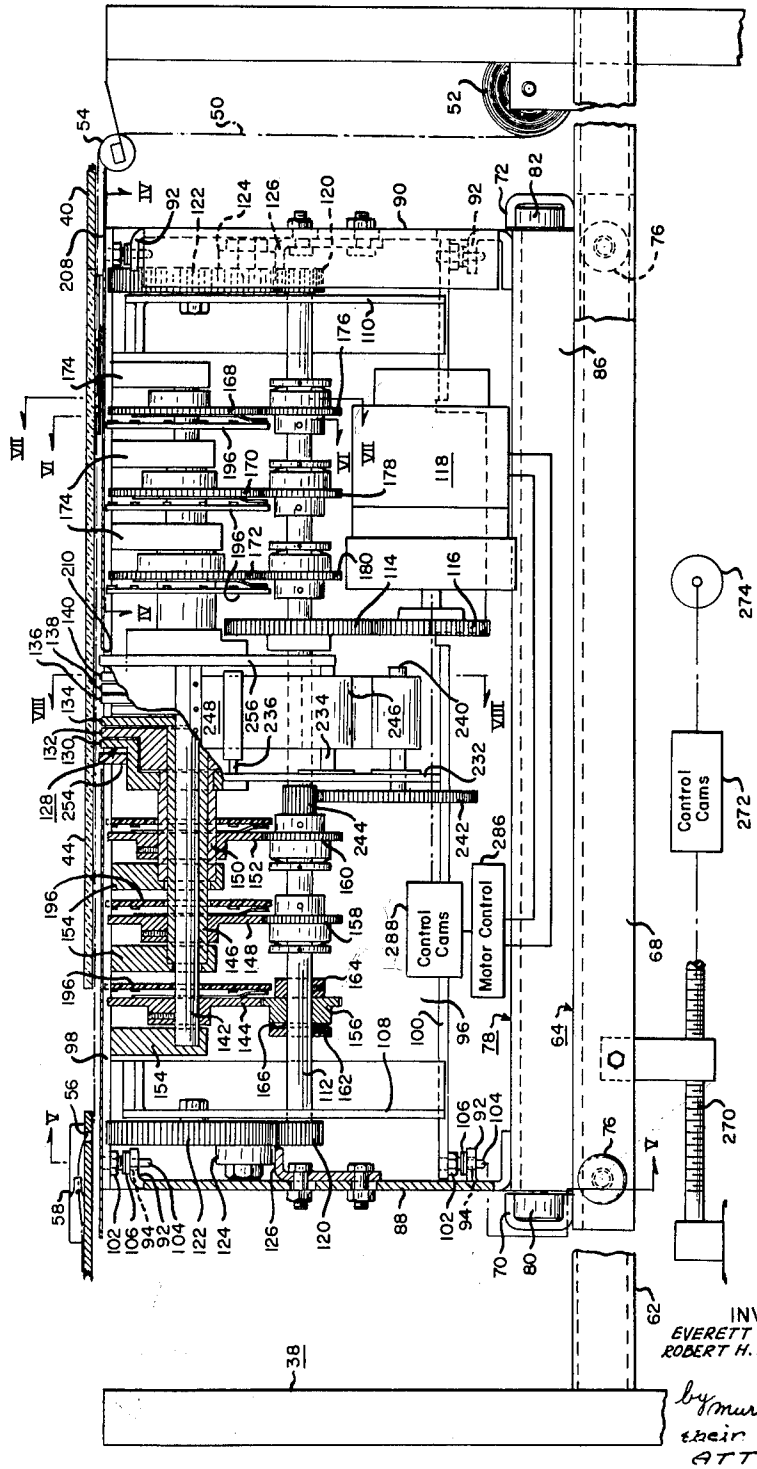
AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 2

Fig. 3.



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AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 3

Fig. 6.

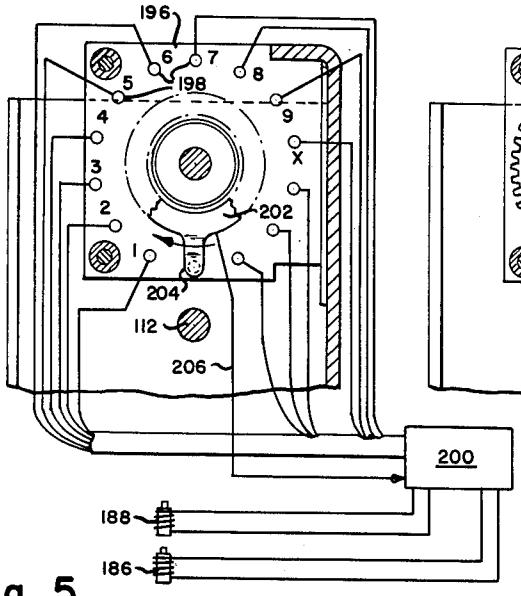


Fig. 7.

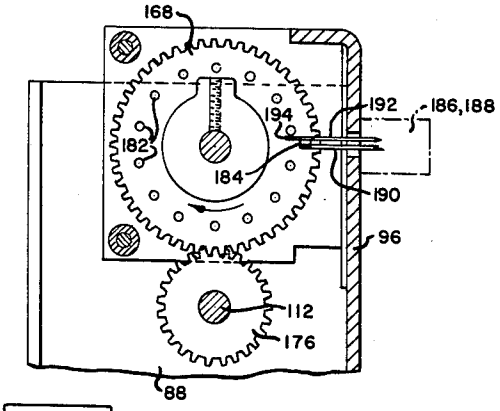


Fig. 5.

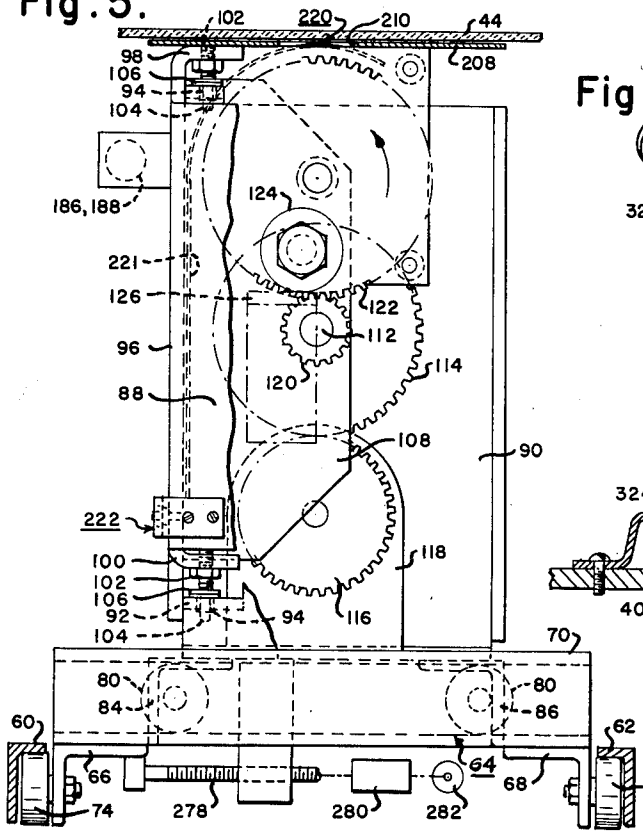


Fig. 11.

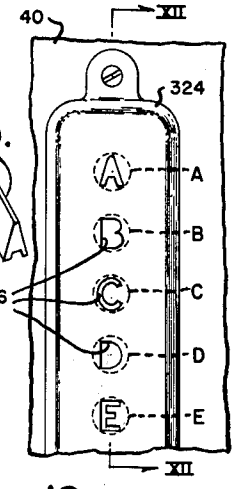
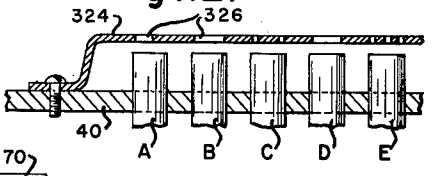


Fig. 13.

Fig. 12.



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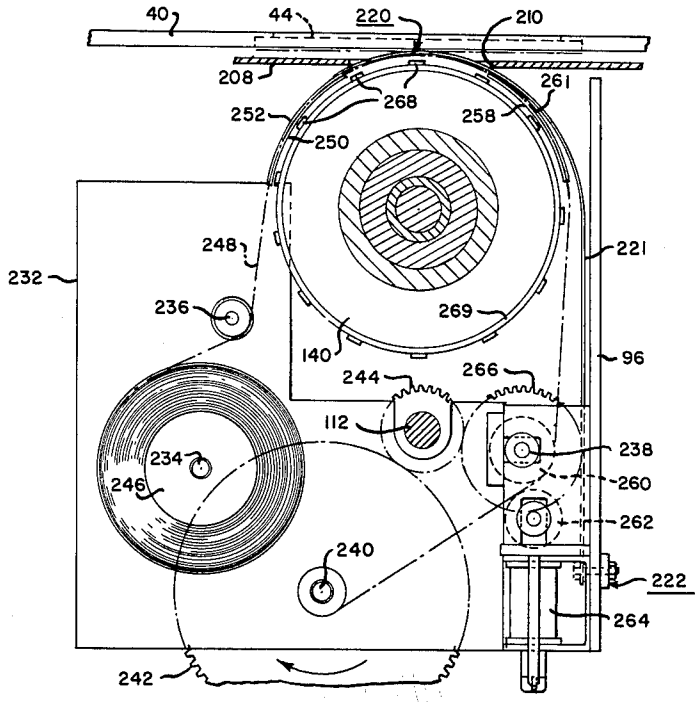
AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 4

Fig. 8.



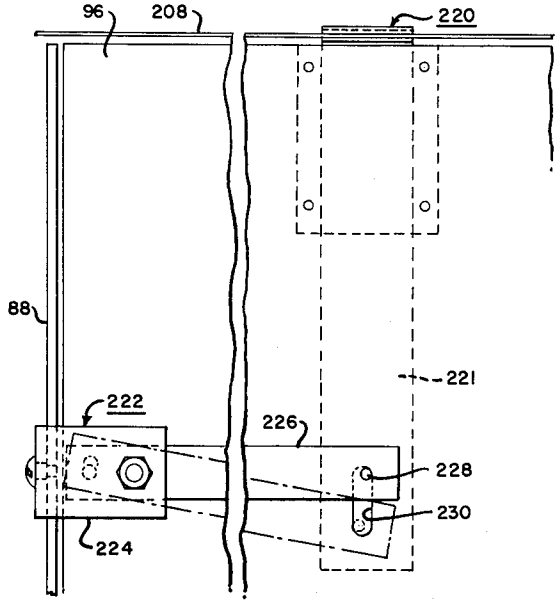


Fig. 9.

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AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 5

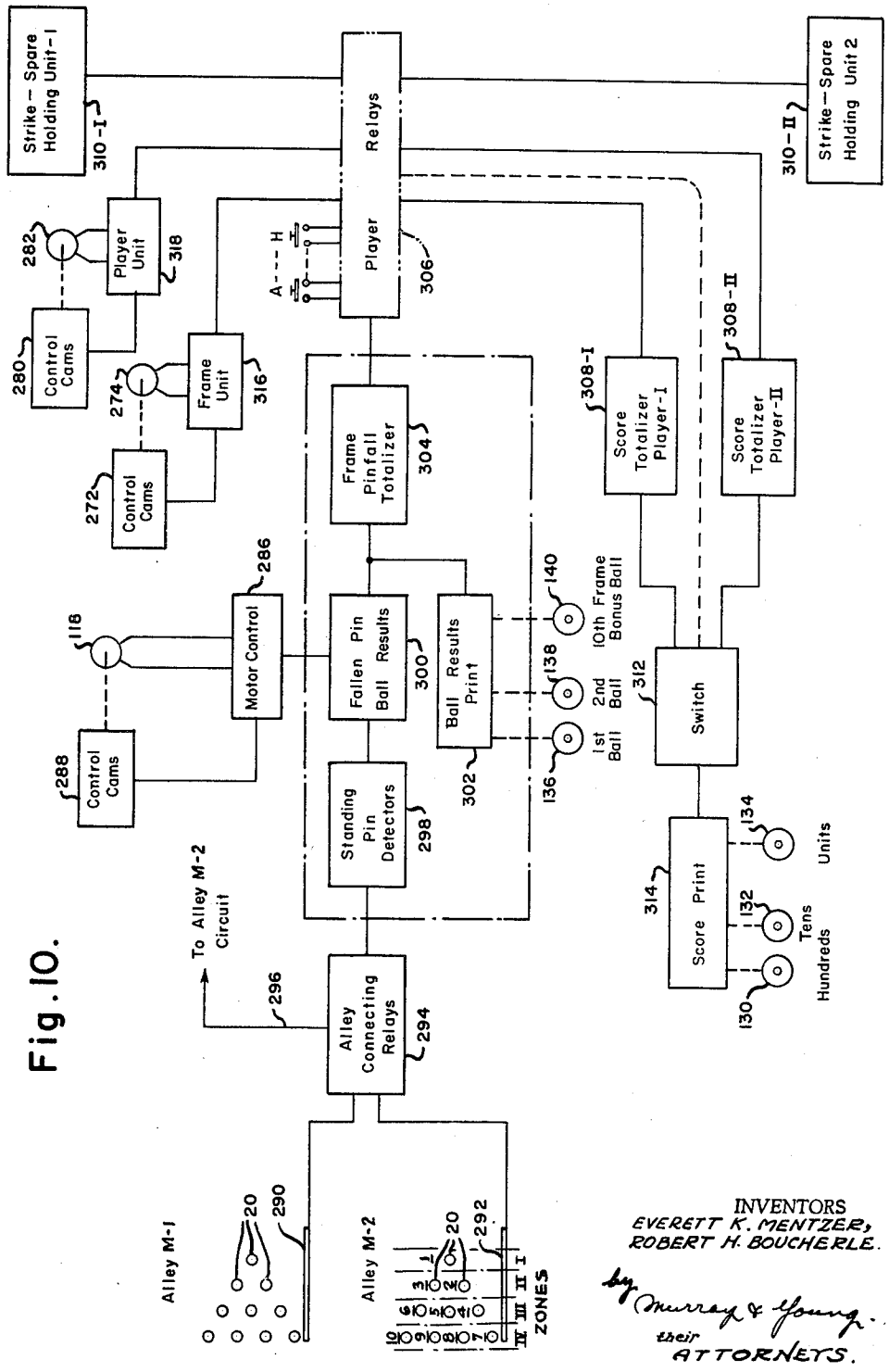

Fig. 10.

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AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962

15 Sheets-Sheet 6

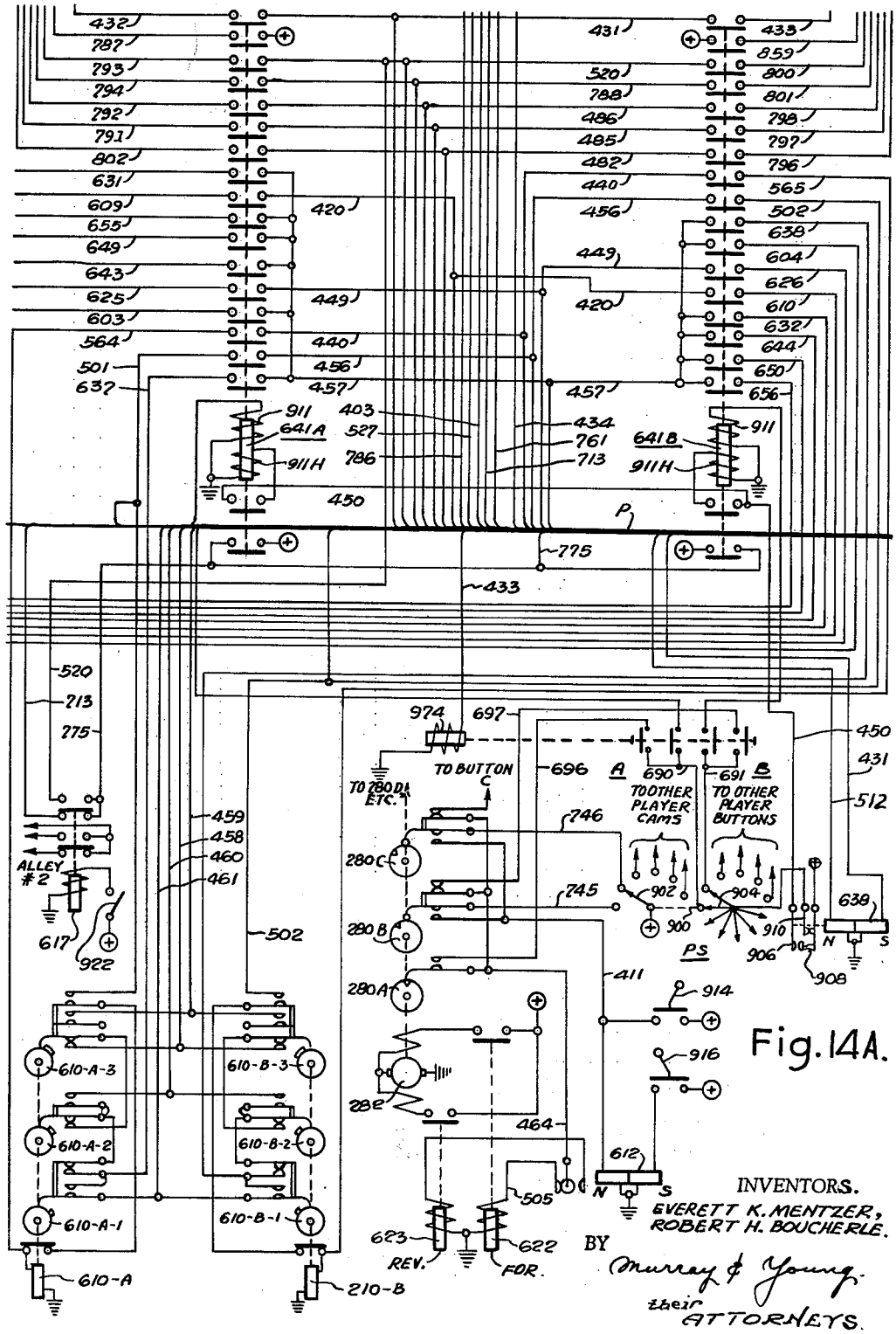

Fig. 14A.

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AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962

15 Sheets-Sheet 7

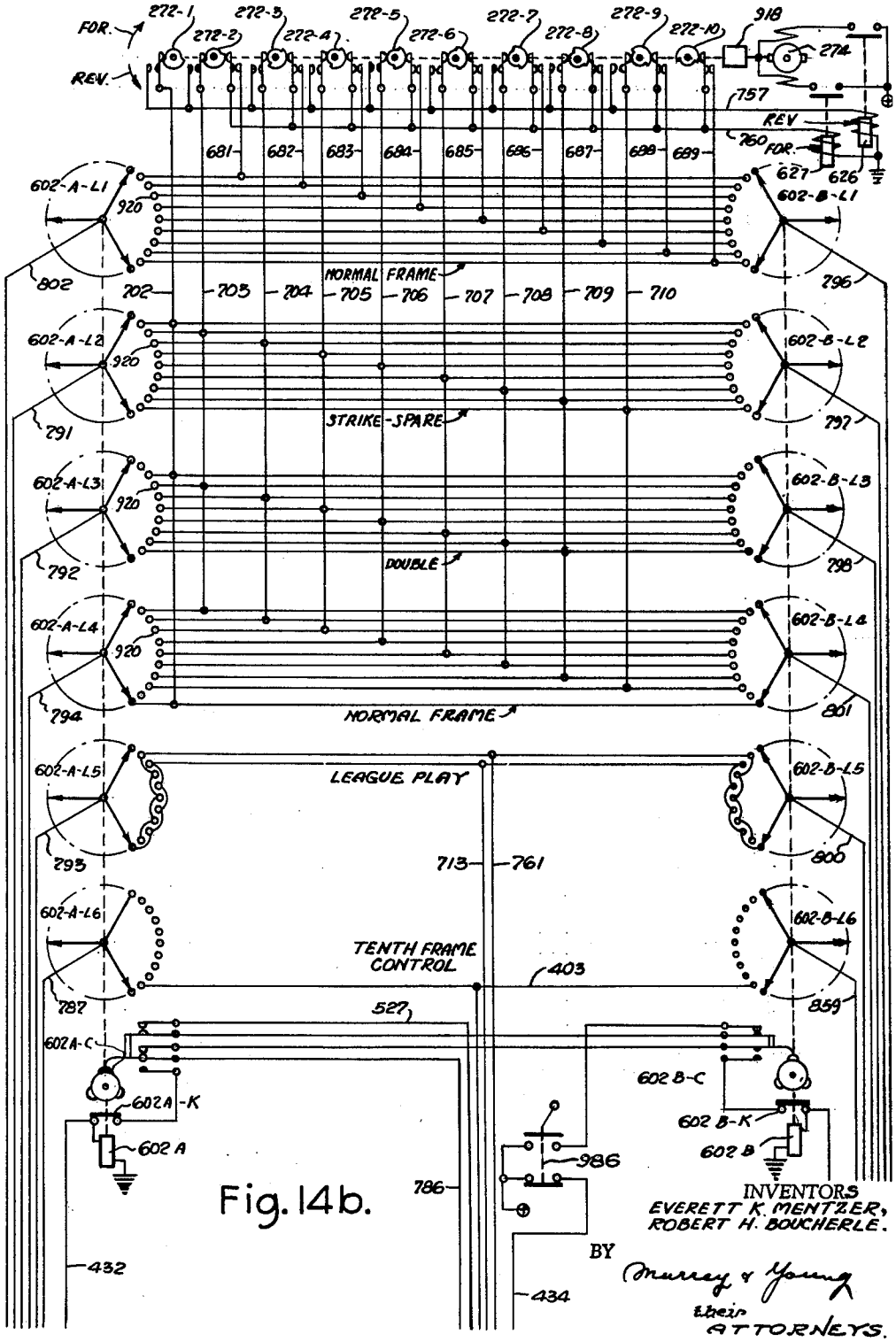

Fig. 14b.

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AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 8

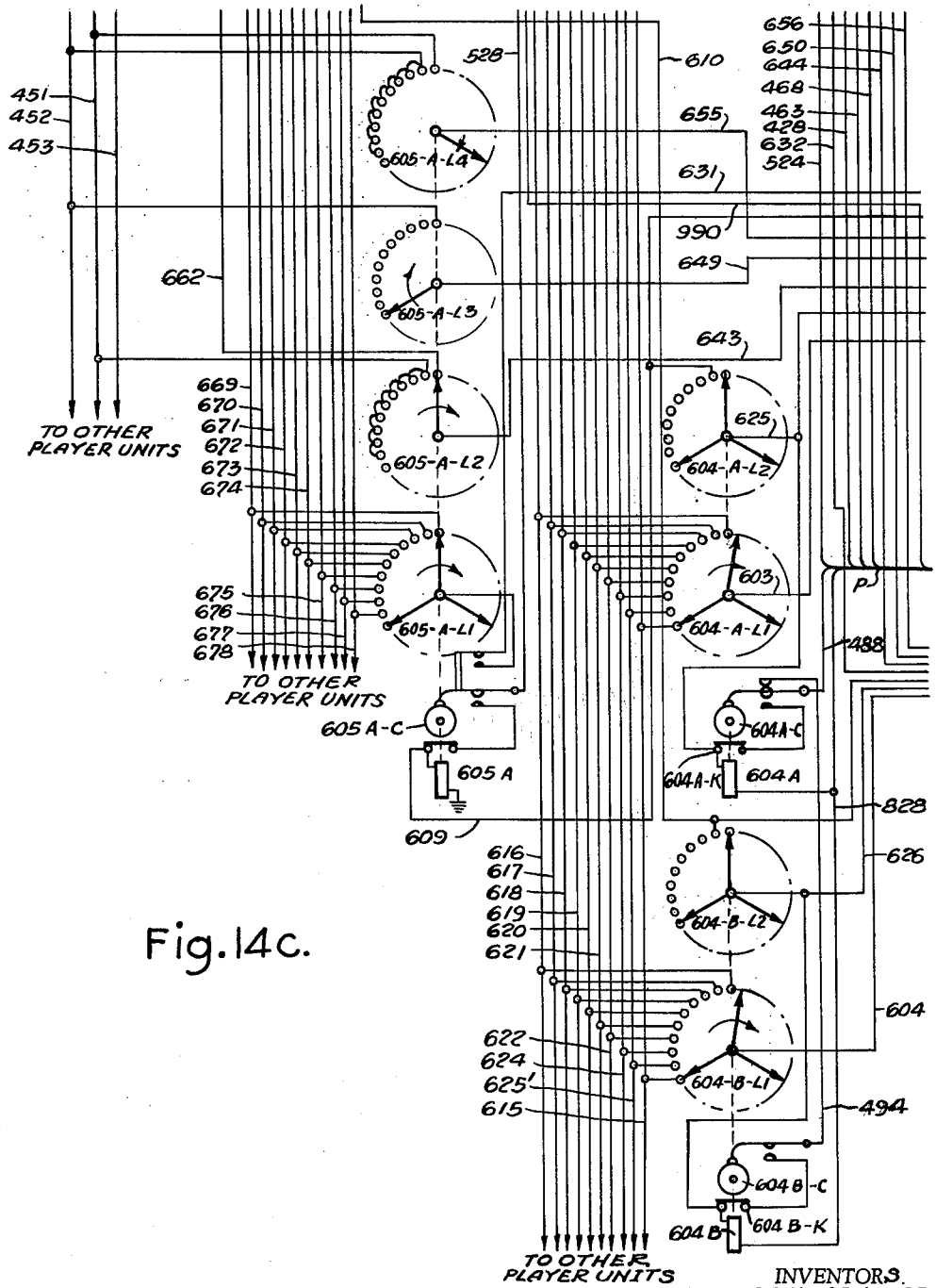

Fig. 14c.

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AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962

15 Sheets-Sheet 9

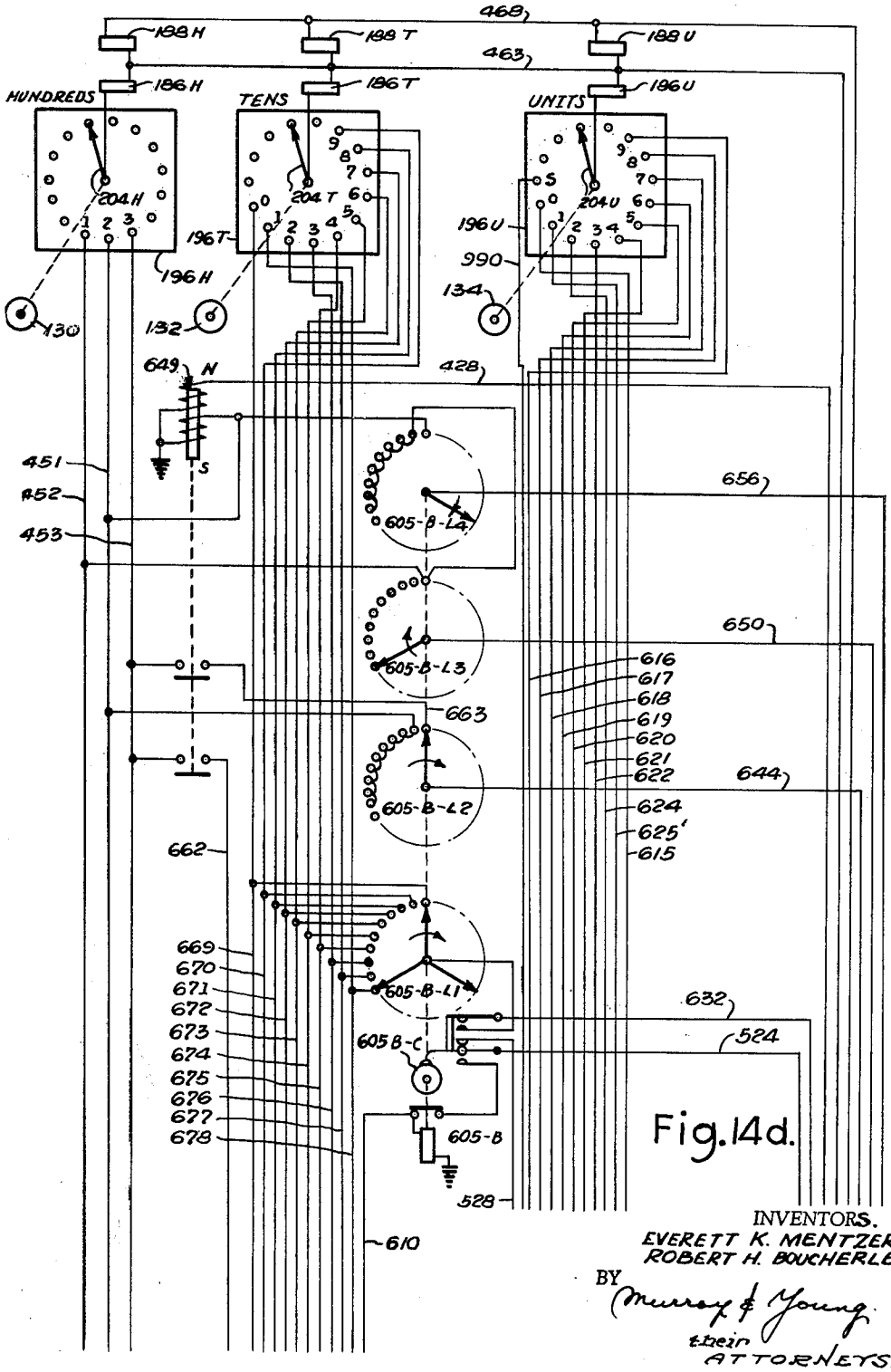

Fig. 14d.

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AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962

15 Sheets-Sheet 10

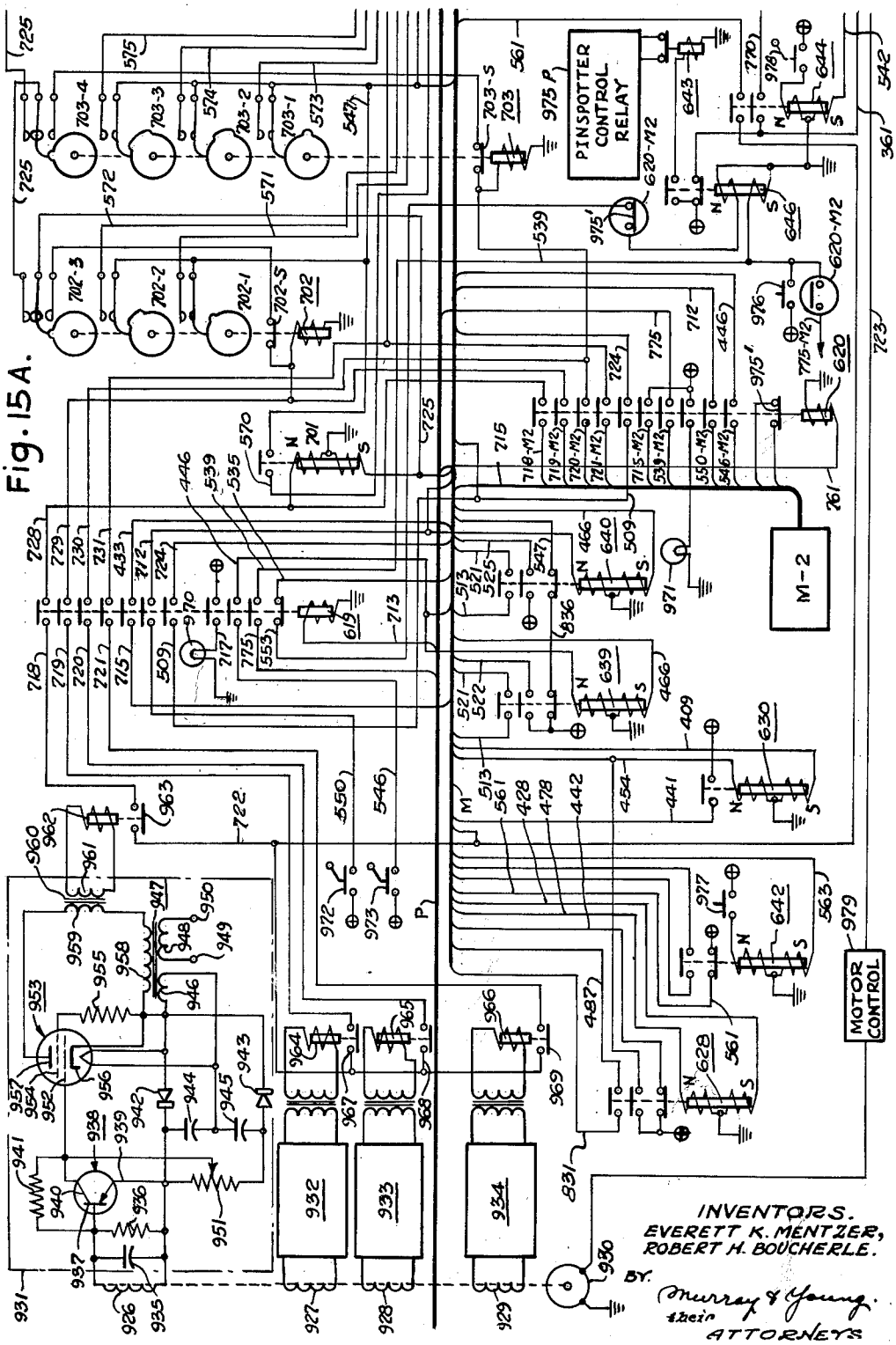

Fig. 15A.

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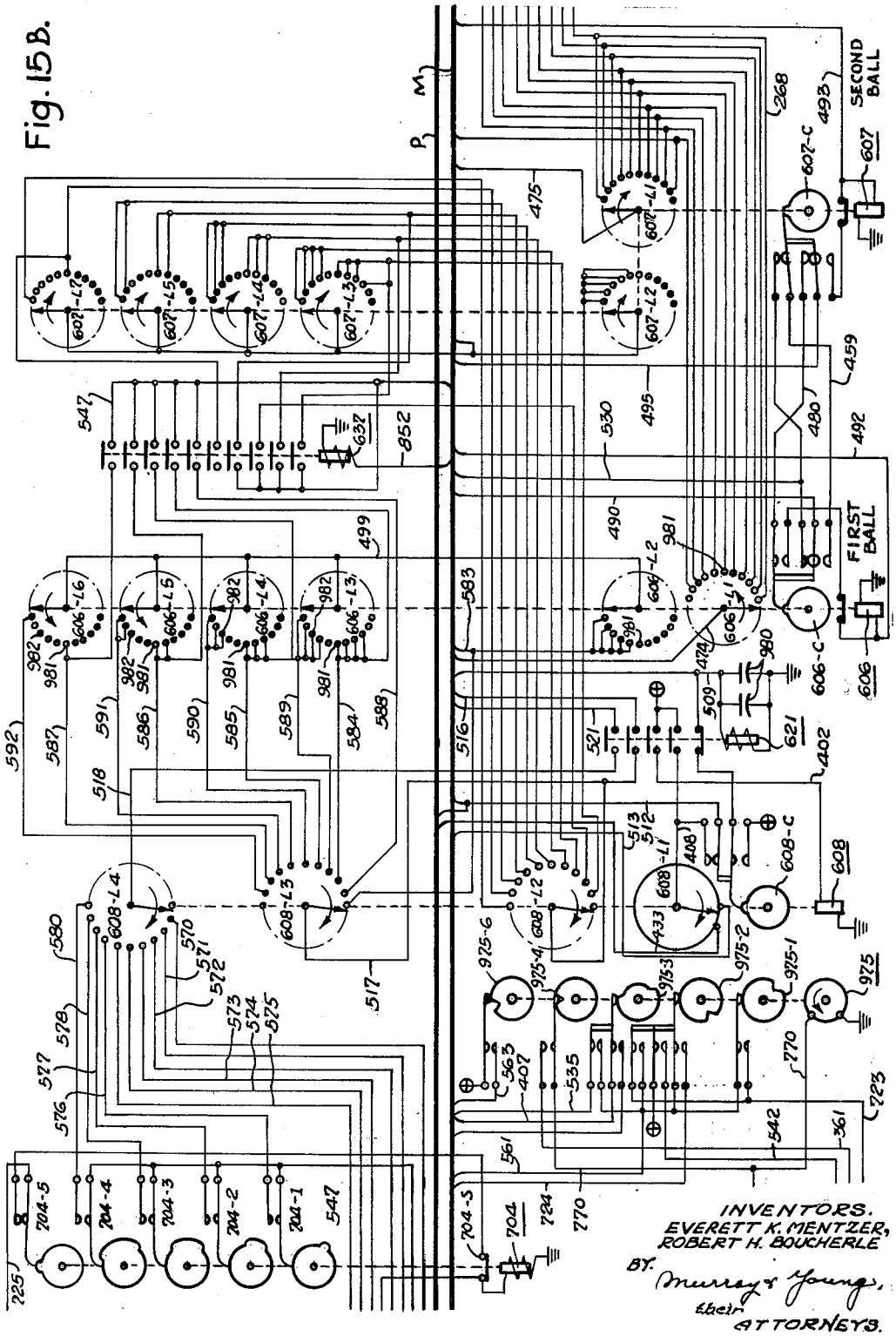
AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962

15 Sheets-Sheet 11

Fig. 15B.

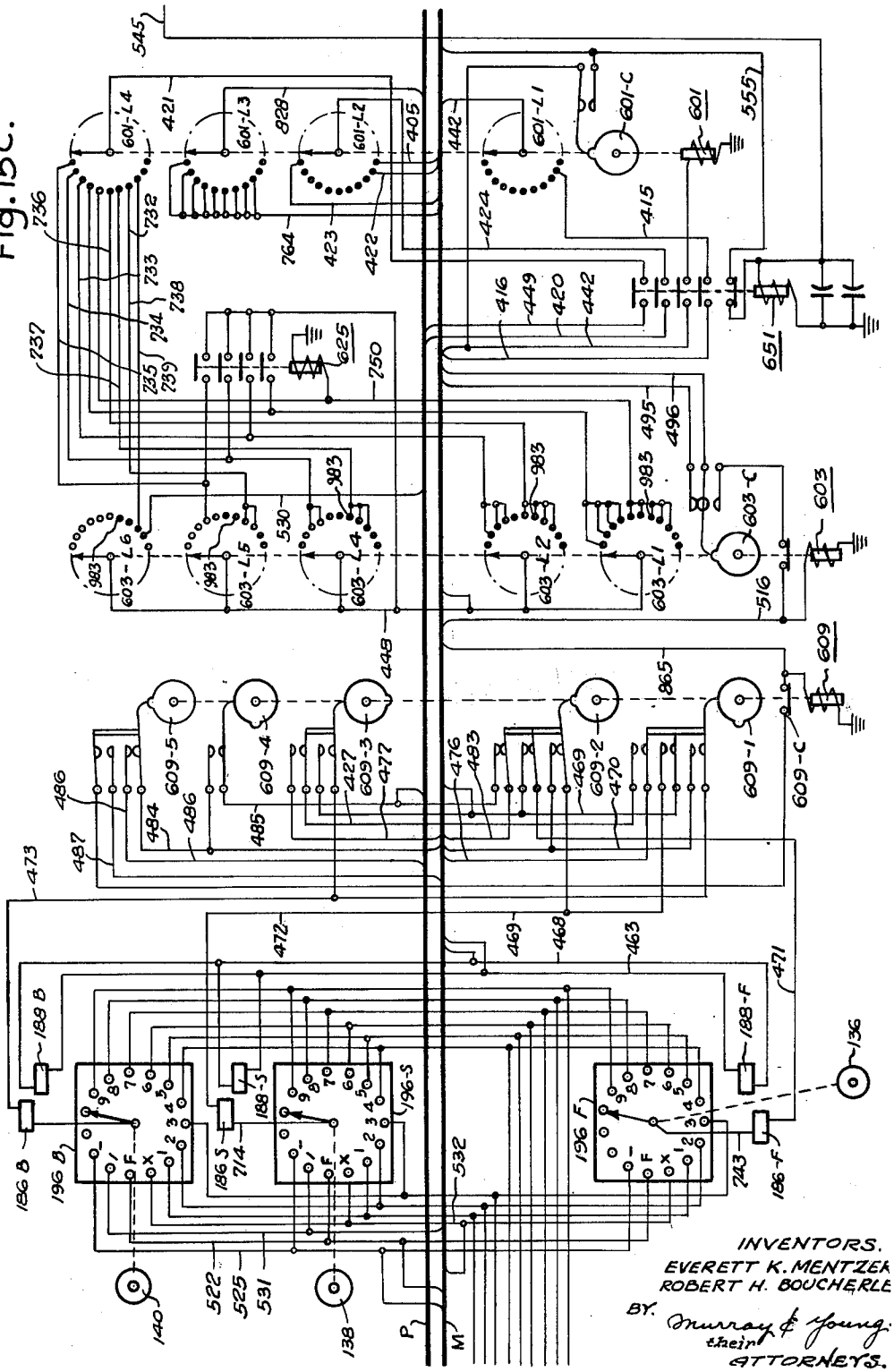


March 10, 1964 E. K. MENTZER ETAL 3,124,355

AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 12

Fig. 15C.



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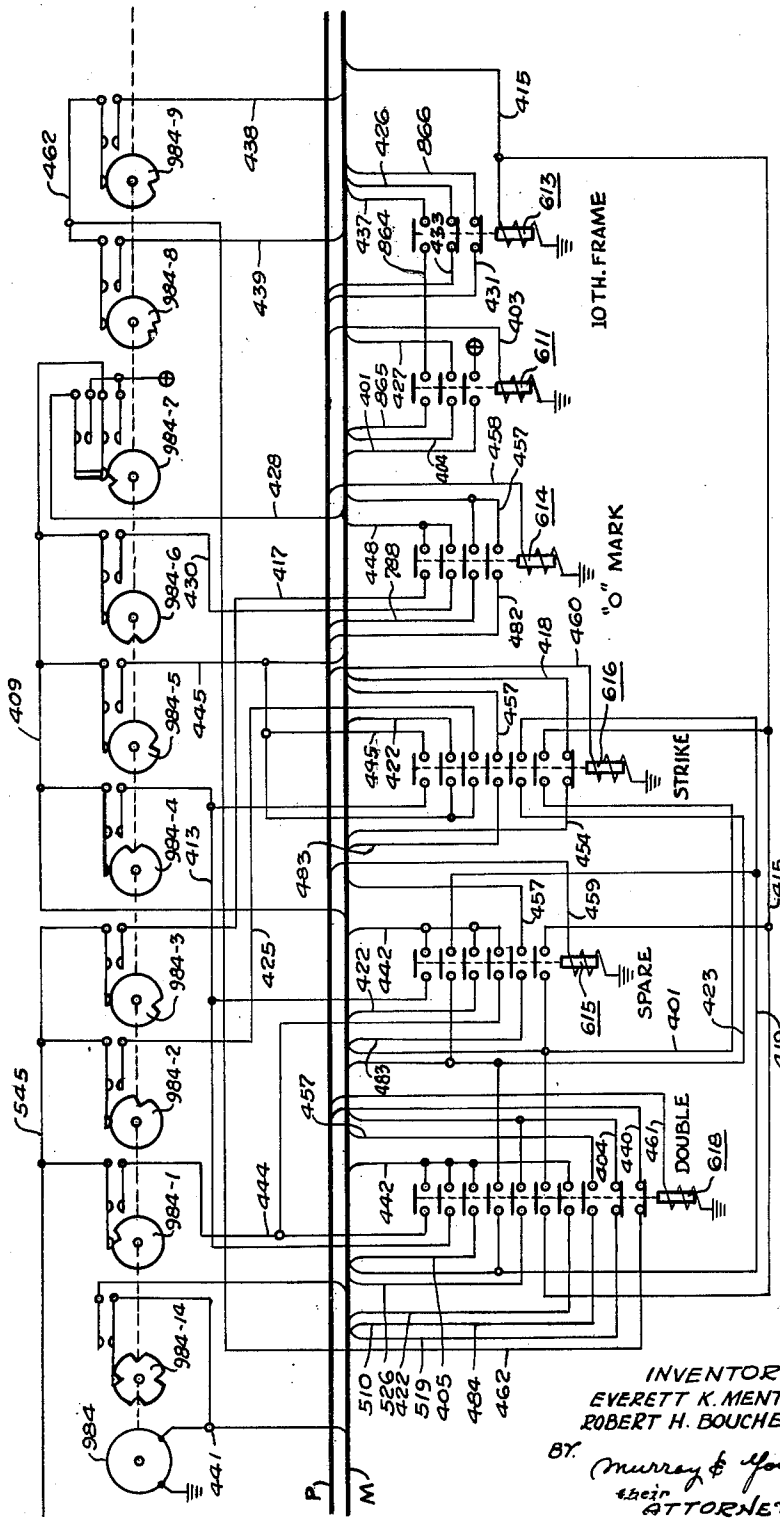
AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 13

Fig. 15D.



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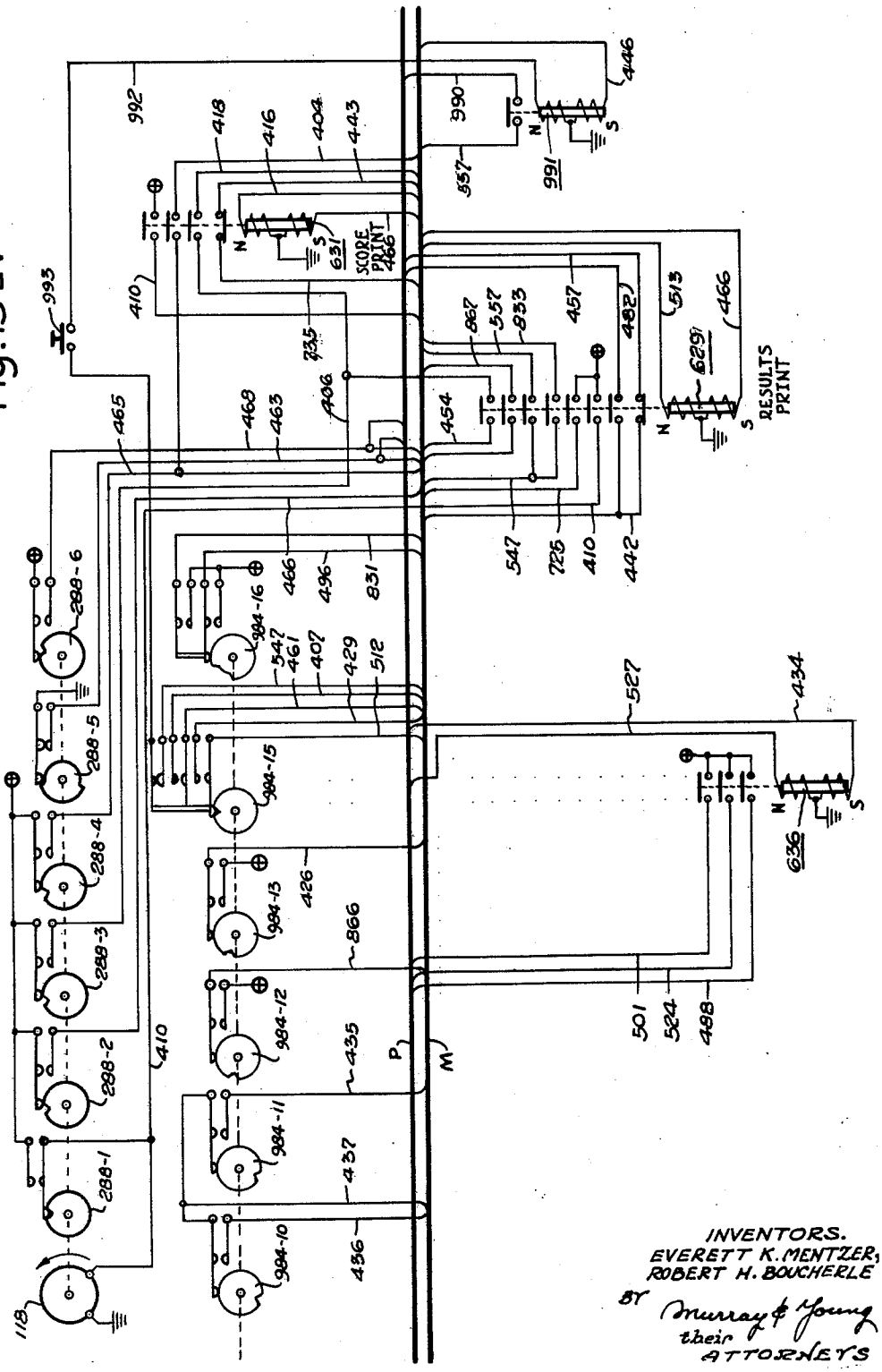
AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 14

Fig. 15E.



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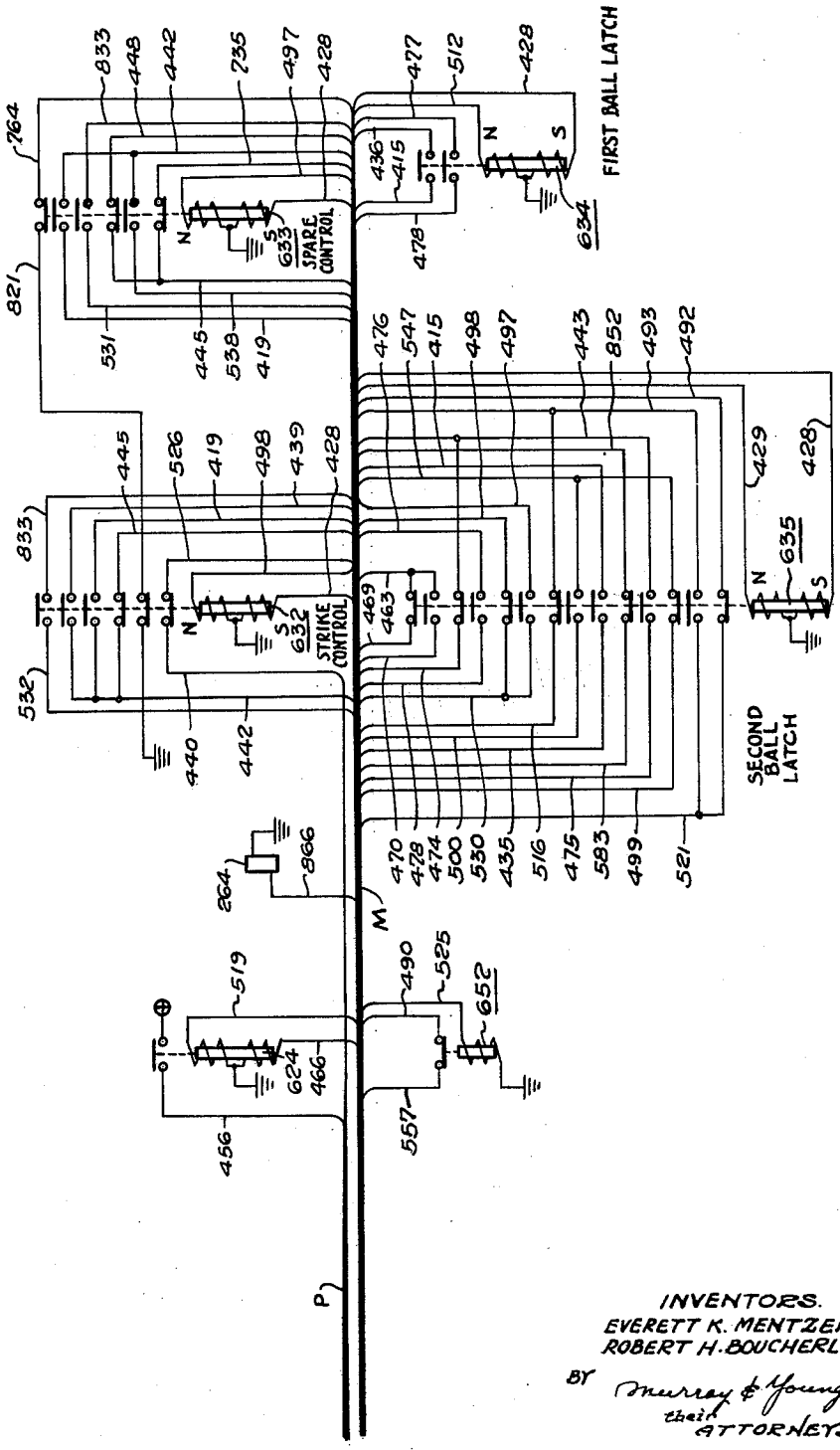
AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

Filed Feb. 9, 1962 15 Sheets-Sheet 15

Fig. 15 F.



United States Patent Office 3,124,355 Patented Mar. 10, 1964

3,124,355

AUTOMATIC SCORING, TOTALIZING AND PRINTING APPARATUS FOR BOWLING GAME

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Filed Feb. 9, 1962, Ser. No. 175,865
2 Claims. (Cl. 273—54)

This invention relates to apparatus for automatically registering, totalizing and printing the score of one or more players in a bowling game. More particularly, the invention relates to apparatus of the type described which may be used whether the bowlers in a particular group are bowling on one or a plurality of alleys and may also be used for league play. This application is a continuation-in-part of our copending application Serial No. 38,091, filed July 7, 1960.

As is well known, a bowling game is normally divided into ten frames, the object being to knock down ten pins arranged in a triangular configuration with one or more ball deliveries during each frame. In the case of tenpins, two balls are allowed for each frame except in the case of a strike where all pins are knocked down by the first ball and the frame ends with the throwing of the first or strike ball. If a bowler knocks down less than ten pins with two balls in any one frame, he is entitled to an immediate score for that frame. On the other hand, if the bowler knocks down ten pins with two balls in any frame, he has made a "spare" which, for that frame, entitles him to a score of ten plus the number of pins knocked down by the first ball in the next frame. Finally, if the bowler achieves a "strike" by knocking down all of the pins with the first ball in a frame, he is entitled, for that frame, to a score of ten plus the total number of pins knocked down by the next succeeding two balls.

In a bowling game there are ten frames, and the foregoing procedure applies for the first nine frames. If a spare is made in the tenth frame, however, one bonus ball is allowed, meaning that the bowler is allowed to deliver three balls in the last frame. On the other hand, if a strike is made in the last frame, the bowler is entitled to two bonus balls, meaning that he still delivers a total of three balls in this last frame. If neither a strike nor spare is made in the last or tenth frame, the bowler is entitled to only two balls for that frame as in any other frame.

The bowling score is usually recorded on charts or blank forms provided by proprietors or operators of bowling alleys. It is generally customary for either the bowler himself or a person designated for this purpose to keep score. After each ball is rolled, the pinfall results of that ball are entered in a box provided in the upper right-hand corner of the score box corresponding to the frame being played. In most cases, after each frame is played, the frame score is written in the appropriate place in a box or part of the score chart corresponding to the particular frame adjacent the name of each player. If a bowler should make, for example, nine pins in a frame, the number nine will be headed in the box provided for that frame adjacent his name. If, on the other hand, a strike or a spare is made on the first or second ball, respectively, of a frame, a symbol well known in scoring the game is placed in the upper right-hand corner of the box representing that frame to indicate the results of the pinfall by a particular ball in the case of a strike, or two balls in the case of a spare. In the case of a strike, two balls must be delivered before appropriate scores in preceding boxes can be entered. In the case of a spare, scoring is delayed until the next or first ball of the next frame is rolled; whereas, in the case of two normal balls

knocking down less than ten pins, the frame score can immediately be added and the play to that point totalized.

Although the manual method of scoring described above has been used for many years, it has certain inherent disadvantages. The bowling game is probably the most difficult of all games to score properly, and when entries are made on a score sheet manually, errors oftentimes arise in counting the number of pins knocked down by any ball and in adding the pinfall results of any frame to the previous score. Furthermore, the scoring procedure is often confusing to beginners and gives rise to discussions and arguments arising in connection with entries on the score charts. Accordingly, it is highly desirable to provide a means for automatically registering the number of pins knocked down in a frame by each ball, as well as strikes and spares, together with apparatus for totalizing and printing the score in each frame.

Systems have been proposed, such as that shown in Millman et al. Patent 2,590,444, for automatically registering strikes, spares and pins knocked down and for totalizing the score in each frame. In a device of this type, however, the ball results and score for each frame are registered on a scoreboard, and the score is then removed or erased when the next frame is played. That is, the score for only one frame is indicated at any one time on the scoreboard, meaning that there is no permanent record of the score achieved in each frame during the bowling game as is the case, for example, when the score is manually entered on a score sheet. The score indicated on a scoreboard may, of course, be manually entered on a score sheet in order to obtain a permanent record, however this involves much the same manual process as is required under the ordinary scoring procedure.

As an overall object, the present invention seeks to provide improved apparatus for detecting, totalizing and printing the score in a bowling game.

More specifically, an object of the invention is to provide an automatic scoring and printing system for a bowling game wherein ball results and scores are entered on a score sheet in a manner such that substantially the entire sheet is visible along with the ball results and frame-to-frame scores of all players achieved during the progress of a game. In this way, the system closely approximates the present manual system of entering scores wherein the entire sheet is visible except when the scorekeeper's hand obstructs a portion of the sheet during the time that an entry is made.

Contrary to what might be expected, the provision of apparatus for achieving the foregoing object is not a simple matter. Unobstructed viewing of a printed sheet during the printing operation is of little importance in the case of the usual printing procedure since the printed sheet is not intended to be viewed or read until after the printing operation is completed. However, in the case of a bowling game score sheet, bowlers are accustomed to viewing substantially the entire score sheet during the game; and any other arrangement might discourage use of the equipment.

In accordance with the invention, the score sheet is formed from material which will permit light to pass therethrough and is supported in close abutting relationship with a substantially flat transparent backing plate such that substantially the entire sheet is visible during the progress of a game, meaning that except during an actual printing operation, all parts of the sheet can be viewed. As will be seen, the use of a transparent, or at least a substantially transparent, plate and a score sheet through which light will pass facilitates illumination of the score sheet by light passing through the plate. Although various different arrangements of the score sheet

can be effected in accordance with the teachings of the invention, it has been found that a transparent or the like backing plate and a score sheet through which light will pass are fundamental essentials.

The printing apparatus must be such that it will facilitate relative movement between the score sheet and printing type and will permit substantially continuous viewing of the score sheet during the progress of a game, although at least a portion of the score sheet will necessarily be obstructed during actual printing of a score, as was mentioned above. As will be understood, the printing apparatus may be embodied in various forms, the specific arrangement shown herein being illustrative of one embodiment. The essential feature of the printing apparatus is that it facilitates substantially the entire sheet being visible during the progress of a game.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings which form a part of this specification, and in which:

FIGURE 1 is a perspective view of a bowling alley with which the scoring, totalizing and printing apparatus of the invention may be used;

FIG. 2 is a top view of the printing arrangement of the invention;

FIG. 3 is a partially broken-away side view of the printing apparatus of the invention showing the arrangement of the printing wheels and the cam means for lifting the printing wheels into engagement with the sheet which is to be printed;

FIG. 4 is a partial top view of the apparatus of FIG. 3 taken substantially along line IV—IV of FIG. 3;

FIG. 5 is a cross-sectional view taken along line V—V of FIG. 3 showing the cam arrangement for elevating the printing apparatus into engagement with the sheet which is to be printed;

FIG. 6 is a cross-sectional view taken along line VI—VI of FIG. 3 showing the electrical contact arrangement for each printing wheel of the printing apparatus of the invention;

FIG. 7 is a cross-sectional view taken along line VII—VII of FIG. 3 showing the stop finger arrangement and indexing mechanism for each of the printing wheels of the invention;

FIG. 8 is a cross-sectional view taken along line VIII—VIII of FIG. 3 showing the carbon paper dispensing and shutter arrangement of the invention;

FIG. 9 is a back view of the printing apparatus of FIG. 3 showing the shutter actuating arrangement of the invention;

FIG. 10 is a block diagram of the automatic detecting, registering and totalizing system of the present invention;

FIG. 11 is a top view of a cover for the player pushbuttons shown in FIG. 2 which will permit each pushbutton to be depressed only by an appropriate key for that pushbutton;

FIG. 12 is a cross-sectional view taken along line XII—XII of FIG. 11;

FIG. 13 is a perspective view of one of the keys usable with the cover of FIGS. 11 and 12;

FIGS. 14A–14D, when placed side-by-side in the following manner, constitute a schematic circuit diagram of the player switches and player totalizing and scoring units of the invention: FIG. 14B above FIG. 14A, FIG. 14C to the left of FIG. 14A, and FIG. 14D to the left of FIG. 14B and above FIG. 14C; and

FIGS. 15A–15F, when placed end-to-end, constitute a schematic circuit diagram of the master circuit of the invention.

Referring now to the drawings, and particularly to FIG. 1, a bowling alley is shown comprising the usual approach area **10** which terminates at a foul line **12**. On the other side of the foul line is the alley proper **14** comprising tongue-and-groove bed stock laid on edge. The alley **14** terminates at a tail plank, **16**, while ahead of the tail plank is a pin deck **18** having ten fiber pin spots **20** thereon. As will be understood, the pins are placed on the pin spots **20** during a bowling game by means of an automatic pin-spotting machine, not shown. On each side of the alley **14** are round bottom gutters **22**, only one of such gutters being shown in FIG. 1. The gutters **22** extend from the foul line **12** to the pin deck **18**; while along the pin deck are gutters **24** which conventionally have flat bottom surfaces, these gutters **24** communicating with the ends of gutters **22** as shown.

Separating successive alleys are division boards **26** which communicate with kickbacks **28**. The kickbacks extend along the length of the pin deck **18** as well as the pit **30** behind the tail plank. A cushion plank **32** extends between the tops of the kickbacks **28** and supports a cushion **34**, substantially as shown. On the side of each kickback **28** is a kickback plate **36** facing the pins on spots **20**.

The printing apparatus of the present invention is carried within a console, generally indicated at **38** in FIG. 1, this console being positioned adjacent the approach area **10**. In an actual installation, usually two printing devices will be positioned within a single console between adjacent alleys to facilitate league play; however, for the purpose of a complete understanding of the invention, the single printing arrangement for the one alley will suffice.

Referring now to FIG. 2, the top **40** of the console **38** is shown and comprises a plate having a rectangular opening **42** cut therein. Covering the major right-hand portion of the opening **42** is a transparent plate **44**, while beneath the plate **44** is a conventional bowling game score sheet comprising a series of player lines each of which is divided into frame boxes numbered one through ten. Within the first nine frame boxes in each player line are two ball results boxes **46**, while in the tenth frame three ball results boxes **48** are provided. In the particular embodiment of the invention shown herein, the transparent plate **44** does not cover the left-hand portion of the score sheet provided for the players' names, the arrangement being such that the name of each player may be manually entered on one of the player lines with a pencil or the like. Adjacent the names of the players are a series of pushbuttons identified by the letters A through H. As will be seen, these pushbuttons are used to position the printing apparatus, hereinafter described, beneath the correct player line. As an alternative to the arrangement shown in FIG. 2, the transparent plate **44** may cover the entire score sheet, in which case a removable card having the names of players thereon may be slipped into a holder adjacent the pushbuttons A–H such that each player's name will be adjacent one of the pushbuttons.

Description of Structure and Operation of Printing Apparatus

Referring now to FIGS. 3 and 5, it can be seen that the score sheet, identified by the numeral **50**, actually comprises a series of such sheets wound upon a paper roll **52** carried within the console **38**. From the paper roll **52** the continuous sheet of successive score sheets passes over a roller **54** which is spring-biased upwardly against the bottom surface of plate **40** and thence underneath the transparent plate **44** to an exit slot **56**. From the slot **56** the continuous roll of score sheets passes into a score sheet clamp and cutoff assembly **58** which, in one position, clamps the forward end of the continuous length of score sheets and, in another position, is adapted to sever the continuous length so as to separate a fully printed score sheet from the next successive score sheet to be printed beneath the transparent plate **44**.

Carried within the console **38** beneath the plates **44** are a first pair of tracks **60** and **62** (FIG. 5) which carry, for reciprocating movement, a first carriage **64**

comprising a pair of angle irons 66 and 68 bolted or otherwise securely fastened to a second pair of tracks 70 and 72 (FIG. 3). Provided on the angle irons 66 and 68 are rollers 74 and 76 adapted to move along the tracks 60 and 62 to facilitate reciprocating movement of the carriage 64 along a path extending parallel to the player lines on the score sheet 50. Carried on the tracks 70 and 72 for reciprocating movement at right angles to the movement of carriage 64 is a second carriage 78 having rollers 80 and 82 adapted to move within the tracks 70 and 72. The carriage 78 comprises a pair of angle irons 84 and 86 to which the rollers 80 and 82 are connected, together with a pair of plates 88 and 90 which extend upwardly from angle irons 84 and 86. The ends of upright plates 88 and 90 furtherest removed from the plane of the drawing are provided with inwardly-bent tabs 92 each provided with an opening which receives a bushing 94. The purpose of the tabs 92 and bushings 94 is to support, for reciprocating movement, a vertically extending plate 96 which, in turn, carries the printing apparatus proper as will hereinafter be described. As shown, the plate 96 is provided with inwardly-bent flanges 98 and 100 at its upper and lower edges, respectively. Carried on the flanges 98 and 100 at the opposite ends thereof are bolts 102 having stub portions 104 which extend downwardly through the bushings 94 in the tabs 92 on plates 88 and 90. Threadedly received on the bolts 102 are stop members 106, the arrangement being such that these stop members 106 will limit the downward movement of plate 96 with respect to plates 88 and 90. The plate 96 may, however, move upwardly from the position shown in FIGS. 3 and 5 by virtue of the stub portions 104 which are slideably received in the bushings 94 in tabs 92. That is, the plate 96 may reciprocate upwardly from the position shown in FIGS. 3 and 5 and then downwardly with the stub portions 104 serving as guides.

Secured to the inner face of the reciprocable plate 96, at either end thereof, are two plates 108 and 110 (FIG. 3) which support a main drive shaft 112 for the printing apparatus proper. The shaft 112 is connected through gears 114 and 116 to printer drive motor 118, the arrangement being such that the drive motor 118 may be actuated to rotate the main drive shaft 112. At the opposite ends of the drive shaft 112 are pinion gears 120, each of which meshes with a larger gear 122 carried on an associated one of the plates 108 or 110. Each gear 122, in turn, has a circular cam 124 bolted to its outer surface; and this cam is adapted to engage the upper surface of a bracket 126 bolted to an associated one of the plates 88 or 90. As is best shown in FIG. 5, the path of rotation of cams 124 on gears 122 is such that they will engage the upper surfaces of the brackets 126 for each revolution of the gears 122. Since the brackets 126 on the plates 88 and 90 are carried on the carriage 78, and since the gears 122 and cams 124 are carried on the reciprocable plate 96, the engagement of the cams 124 with the top surfaces of the brackets 126 will cause the plate 96 and all of the components carried thereby to move upwardly on the stub portions 104 of bolts 102 and then downwardly into their original starting positions. It will be noted that the printer drive motor 118 is carried on the plate 96 so that it also moves upwardly with the shaft 112 when the cams 124 engage the brackets 126.

Above the shaft 12 is a printing wheel assembly (FIG. 3), generally indicated at 128. Since the embodiment of the invention shown herein is used for printing the ball results and score in a bowling game, there are six printing wheels numbered 130, 132, 134, 136, 138 and 140. As will hereinafter be seen, each of the printing wheels 130—140 has a plurality of printing or type characters circumferentially spaced around its circumference. The first three printing wheels 130, 132 and 134 are employed to print the score in the frame boxes shown on the score sheet of FIG. 2. In this respect, wheel 134 is employed to print units, wheel 132 prints tens, and wheel 130 prints hundreds. The printing wheels 136, 138 and 140, on the other hand, are employed to print the ball results in the ball results boxes 46 on the score sheet. In this respect, the wheel 136 is employed to print the first ball results; the wheel 138 is employed to print the second ball results; and the wheel 140 is used only in the tenth frame where there are three ball results boxes 48. That is, the wheel 140 is used only when a bonus ball is rolled in the tenth frame, this wheel serving to print the ball results of the bonus ball.

With reference to the printing wheel 134, it is connected through a central shaft 142 to a gear 144 which is keyed or otherwise securely fastened to the shaft 142 so as to rotate therewith. The printing wheel 132, on the other hand, is connected through a first tubular shaft 146 to a gear 148, this gear being keyed to the shaft 146. Finally, in a similar manner, the printing wheel 130 is connected through a third outer tubular shaft 150 to a third gear 152. As will be understood, by virtue of the coaxial relationship of the shafts 142, 146 and 150, each of the printing wheels 130, 132 and 134 may rotate independently of the others. The shafts 142, 146 and 150 are all supported on plastic bearing supports 154 extending outwardly from the vertically reciprocable plate 96 such that the gears 144, 148, 152 and their associated printing wheels 130–134 will move upwardly with the plate 96 when cams 124 engage the brackets 126.

As shown in FIG. 3, the gears 144, 148 and 152 engage gears 156, 158 and 160, respectively, each of the latter gears being slideably received on the main drive shaft 112. On one side of each gear 156, 158 and 160 is a bushing 162 secured to the shaft 112; while the other side of each gear is a second bushing 164 also secured to the shaft 112. Between the bushing 162 and each of the gears 156, 158 and 160 is a leaf spring 166, the arrangement being such that the spring 166 will urge its associated gear 156, 158 or 160 into engagement with the bushing 162 whereby the frictional engagement between the bushing 162 and its gear 156, 158 or 160 will cause the gear to rotate when shaft 112 is rotated, thereby rotating its gear 144, 148 or 152 and its associated printing wheel. When, however, one of the gears 144, 148 or 152 is braked or positively stopped, the respective gear 156, 158 or 160 will also stop and slide on the shaft 112. That is, the frictional engagement between each gear 156, 158 or 160 and its associated bushing 164 is such that it will rotate one of the gears 144, 148 and 152 and its associated printing wheel only in the absence of any braking applied to the latter gears. In this respect, the assemblies of gears 156, 158 and 160 comprise slip clutch arrangements.

Referring now to the ball results printing wheels 136, 138 and 140, each of these is connected to an associated gear 168, 170 and 172, respectively. These printing wheels are connected to the gears 168, 170, 172 through shafts similar to shafts 142, 146 and 150 and are supported on plastic bearing blocks 174 extending outwardly from the reciprocable plate 96. Each gear 168, 170 and 172 meshes with an associated gear 176, 178 or 180 connected in a slip clutch arrangement similar to the gears 156, 158 and 160 already described.

Referring now to FIGS. 4 and 7, it will be noted that the gear 168 is provided with a plurality of drill holes 182 circumferentially spaced around its one face, although these may be replaced with projecting lugs if desired. In addition, the gear 168 is provided with a projection 184 extending outwardly from its one face. Each of the gears 144, 148, 150, 172, 170 and 168 is identical in construction, and in this respect it will be appreciated that each gear operates in the same manner. With reference to FIG. 4, it will be seen that each gear is provided with two control solenoids, the solenoids for gear 168 being identified by the numerals 186 and 188, respectively. Solenoid 188 is provided with an arm 190 having an end projec-

tion which lies in the path of travel of the projection 184 on gear 168. Solenoid 186, on the other hand, is provided with an arm 192 having a detent 194 on its forward end adapted to fit into any one of the drill holes 182. As will hereinafter be seen, the cycle of operation of the printing apparatus is initiated by energizing the motor 118 to rotate each of the gears 144, 148, 150, 172, 170 and 168. When the motor 118 is energized, the gears all tend to rotate in the direction indicated by the arrow in FIG. 7 for gear 168. It will be seen, however, that the projection 184 on each gear which engages arm 190 will prevent rotation. Accordingly, when the motor 118 is energized, the solenoids 186 are also energized to simultaneously pull all of the arms 190 out of the path of travel of their associated projections 184 to permit the gears to rotate. With reference to gear 168 in FIG. 7, its associated solenoid 186 may be energized at any time during rotation of the gear 168 to pull the detent 194 into an associated one of the drill holes 182, thereby stopping the gear 168 and its clutch gear 176 on the main drive shaft 112. In this manner, a selected one of the printing characters or type on any one of the printing wheels may be stopped at the top of the wheel adjacent the score sheet 50 by energizing appropriate ones of the solenoids 186 in timed relationship with respect to the initial energization of solenoids 188.

The solenoid 186 for each printing wheel is energized by means of an arrangement shown in FIG. 6. Thus, there is associated with each printing wheel an insulating board 196 carried adjacent an associated one of the gears 144, 148, 150, 172, 170 and 168. Only that insulating board 196 associated with gear 168 is shown in FIG. 6. It will be noted that the insulating board carries a plurality of circumferentially spaced electrical contact points 198, each of said contacts being connected through an associated lead to a control circuit, schematically illustrated at 200. Carried on the backside of gear 168 is a circular member 202 having a radially-extending spring finger 204 adapted to engage each of the contact points 198 in succession as the gear 168 rotates. The member 202, in turn, is connected through a wiper brush, not shown, and lead 206 to the control circuit 200. Since the gear 168 is connected to the bonus ball results printing wheel 140, it has thirteen contact points connected through associated leads to the control circuit 200. Nine of the contact points represent the numerals 1–9; one contact represents a blow (—); one a strike (X); one a spare (/); and the last one a foul (F). The control circuit 200 is hereinafter fully shown and described in FIGS. 15A–15F. At this ponit, however, it will be sufficient to state that when a bonus ball is rolled in the tenth frame of a game, the number of pins knocked down by that ball will cause an associated one of the contact points 198 to be energized through the control circuit 200. If, for example, six pins were knocked down by the last or bonus ball, the number six contact 198 will be energized. Thereafter, when the motor 118 is energized as well as the solenoids 188, the member 202 will rotate until the radially-extending spring finger 204 engages contact number six. At this point, a circuit will be completed through lead 206 and the control circuit 200 to energize the solenoid 186 for gear 168, thereby pulling the arm 192 (FIG. 4) inwardly toward the outer face of the gear to force the detent 194 into the number six drill hole shown in FIG. 7. At this point, the gears 168 and 176 stop while the drive shaft 112 continues to rotate. In this manner, the numeral six will be stopped at the top of printing wheel 140; and when the vertical plate 96 is elevated upwardly by the cams 124, this numeral six will be pressed against the score sheet 50.

In the practice of the invention, the motor 118 is initially energized, and thereafter the solenoids 188 will be momentarily energized to pull the arms 190 out of the paths of detents or projections 184, thereby permitting the printing wheel gears to rotate. Each wheel will thereafter be stopped at a predetermined angular position determined by which one of its contacts 198 is energized. If, however, none of the contacts is energized, the printing wheel will rotate through a complete revolution until the projection 184 again engages the arm 190 to stop the wheel, at which point there are no characters or type at the top of the printing wheel. The gear ratios of the various gears in the printing apparatus are such that each printing wheel may be rotated through a complete revolution before the gears 122 complete one cycle or revolution to engage the cams 124 with the brackets 126. Thus, assuming that intelligence is fed into the control circuit 200 for each of the printing wheels, each printing wheel will be positioned at a particular point and ready to print on the score sheet 50 before the cams 124 engage brackets 126 to elevate the printing wheels into engagement with the score sheet.

With reference now to FIGS. 2, 3, 5 and 8, it will be noted that a plate 208 is carried on the upper flange 98 of the vertical plate 96. This plate, of course, will move parallel to the player lines shown in FIG. 2 with movement of carriage 64, and will also move perpendicular thereto along the frames with carriage 78. Cut into the plate 208 is an opening or aperture 210 through which the tops of the printing wheels project. The plate 208 is opaque and light-colored to provide a light background for the printed material produced on the underside of the translucent score sheet 50 such that this printed material may be viewed from the top of the translucent sheet through the transparent plate 44. In order to provide an uninterrupted light background for the complete score sheet, the plate 208 must have larger transverse dimensions than the score sheet itself as shown in FIG. 2. That is, when the aperture 210 and the printing wheels underneath are at the lowermost player line H as shown in FIG. 2, the plate 208 must extend upwardly as viewed in FIG. 2, for a sufficient distance to still cover the entire score sheet. Similarly, when the aperture 210 is at the top of the score sheet, the plate 208 must extend downwardly for a sufficient distance so that it still covers the entire score sheet. Furthermore, the length of the plate 208 from left to right as viewed in FIG. 2 must be sufficient to cover the entire score sheet regardless of whether the aperture 210 and the printing wheels beneath are at the extreme left or right end of the score sheet. Stenciled or otherwise provided on the plate 208 is a large arrow 212 comprising a solid pointer 214 having a pair of lines 216 and 218 extending to the right as viewed in FIG. 2, with the space between the lines 216 and 218 being light-colored as the remainder of the plate 208. As will hereinafter be seen, a bowler will push the button A–H adjacent his name before he bowls, and means are provided for moving the carriage 78 upwardly or downwardly until the aperture 210 is under the player line corresponding to the pushbutton that was depressed. In addition, the carriage 64 will be moved to position the aperture 210 over the proper frame to be played. Let us assume, for example, that the player corresponding to the pushbutton G depressed his appropriate button. At this point the carriage 78 will be moved to the player line G, and the carriage 62 will be moved to the proper frame for that player. The arrow 212 serves the important function of giving a positive indication of which player is bowling at any one time. That is, if a player G should mistakenly push button F, then the arrow 212 will, of course, point to player line F rather than the proper player line G, thereby alerting all bowlers to the fact that the player has pushed the wrong button. This condition may be corrected by merely depressing pushbutton G rather than F, whereupon the aperture 210 and the arrow 212 will move to the proper player line. It will be noted that the lines 216 and 218 extend downwardly from the aperture 210 to the extreme right edge of the plate 208. Thus, the arrow will appear regardless of which frame is being played, and by virtue of the fact

that the space between the lines 216 and 218 is light-colored, any scores which appear between these lines may be viewed through the transparent plate 44. Thus, when a score is to be entered in previous frame boxes after the execution of a bowling game "mark" such as a strike or spare, the plate 208 and aperture 210 will move to the left as viewed in FIG. 2. However, by virtue of the separation of lines 216 and 218, the ball results in the succeeding frames will not be obscured.

Referring now to FIGS. 5 and 8, it will be seen that the aperture 210 in plate 208 is covered with a shutter 220 which comprises a flexible strip 221 of metal carried within appropriate guides, not shown, so as to curve upwardly over the tops of the printing wheels. The lower end of the flexible metal strip is connected to a shutter actuating mechanism, generally indicated at 222. The shutter actuating mechanism is possibly best shown in FIG. 9 and comprises an L-shaped bracket 224 which is secured to the right plate 88. Pivotally carried on one arm of the bracket 224 is a shutter actuating arm 226 having a pin 228 at its forward end which projects through a slot 230 in the reciprocable plate 96 and engages the lower end of the flexible steel strip 221. When the cams 124 do not engage brackets 126 in the plate 96 and the printing apparatus is not elevated, the shutter operating arm 226 will be in the position shown by the full lines in FIG. 9 whereby the upper end of the steel strip 221 will pass over and cover the aperture 210 in plate 208. When, however, the plate 96 and its associated printing apparatus are moved upwardly by the cams 124, the pin 228 will anchor the lower end of the flexible steel strip 221 whereby its upper end will move out of the aperture 210, thereby exposing the printing wheels to the score sheet 50. Thereafter, when the plate 96 and its associated printing apparatus move downwardly, the shutter actuating arm 226 will force the steel strip 221 upwardly whereby it will again cover the aperture 210. The shutter 220 is light-colored like the plate 208 and provides a means whereby a continuous light background is provided for the printed material on the score sheet. The shutter 220, however, provides a means whereby the aperture 210 is uncovered when a printing operation is to be performed.

With reference now to FIGS. 3 and 8, carried on the reciprocable plate 96, at right angles thereto, is a plate 232 which carries the carbon roll assembly for the printing wheels. As best shown in FIG. 8, four shafts extend outwardly from the plate 232, these shafts being indicated by the numerals 234, 236, 238 and 240. Carried on the end of shaft 240 is a gear 242 which meshes with a pinion gear 244 on the main drive shaft 112. the arrangement being such that the shaft 240 will be rotated in the direction of the arrow shown in FIG. 8 each time the main drive shaft 112 is rotated. Carried on the shaft 234 is a roll of carbon paper 246. From roll 246 the ribbon 248 of carbon paper passes over roll 236 and thence between curved plates 250 and 252 carried between the opposite end plates 254 and 256 (FIG. 3) of a cage assembly which surrounds the printing wheels. From the plates 250 and 252, the carbon ribbon 258 passes over the tops of the printing wheels and thence through a second pair of curved plates 258 and 261 also carried by the aforesaid cage assembly. Finally, the carbon ribbon 248 passes over a drum 260 on shaft 238 and thence to a reel on shaft 240. Beneath the drum 260 is a roller 262 on a solenoid 264, the arrangement being such that when the solenoid is deenergized the roll 262 will not be in contact with the drum 260, but when it is energized it will be in contact with drum 260. The shaft 238 and drum 260 are driven through gear 266 which, in turn, is connected to the pinion gear 244. The reel on shaft 240 will slip and remain stationary whenever tension is on the carbon ribbon 248. When, however, the solenoid 264 is energized to move roller 262 into contact with drum 260, the carbon ribbon 248 will be unwound from reel 246 and the slack between drum 260 and shaft 240 will be taken up. Means, not shown, are provided to energize the solenoid 264 and advance the carbon ribbon each time a first ball cycle is started for each player, thereby presenting a new carbon surface for the next printing operation.

As will be understood, the upper side only of the carbon ribbon is provided with the usual ink-like material whereas the underside is not. Thus, when any one of the printing characters 268 is at the top of the printing wheel 140, for example, and the plate 96 is forced upwardly by cams 124, a printing character will press the carbon paper against the score sheet 50 to produce a printed character thereon. This printed character may be viewed through the transparent plate 44 while the opaque plate 208 provides a light-colored background for the printed material on the score sheet.

In the particular embodiment of the invention shown herein, the printing characters 268 are formed on a rubber or the like strip 269 which is wound about the printing wheel 140 and secured thereto. In order to effectively print on the underside of the score sheet, either the printing characters themselves must have a certain degree of resiliency or the plate 44 must have this resiliency in order to produce a "seating" effect of the characters against the score sheet in somewhat the same manner as a conventional rubber stamp. Another analogy is a conventional typewriter wherein the platen is semi-resilient to receive the metal type bars. Thus, if the type is resilient or semi-resilient, the transparent plate 44 may be rigid. If, however, the printing characters or type are rigid and rigidly mounted on the printing wheel, then the transparent plate 44 must have a semi-resilient character. An example of a semi-resilient material which is also transparent and suitable for this purpose is vinyl. Still another possibility is to have rigid type resiliently mounted on the printing wheel (i.e., metal type mounted on rubber) in which case the transparent plate 44 may also be rigid.

It will be apparent that the ball results printing wheels 136, 138 and 140 should print in the upper right-hand corner of each frame box on the score sheet; whereas the score results wheels 130, 132 and 134 should print directly in the center and below the ball results boxes of each frame box. This, of course, may be accomplished by offsetting the axes of one set of wheels with respect to those of the other set. In the embodiment of the invention shown, however, the axes of all printing wheels are coincident and the printing characters on wheels 136, 138 and 140 are offset to the right as viewed in FIG. 8 with respect to those on wheels 130, 132 and 134 to achieve the desired result.

Referring again to FIG. 3, it will be noted that the carriage 64 is connected to a worm gear 270, this worm gear being connected through control cams 272 to a frame travel motor 274. In a somewhat similar manner, the carriage 78 is connected to a worm drive 278 (FIG. 5) carried on the carriage 64. The worm drive 278 is connected through control cams 280 to a player travel motor 282. Finally, the printer drive motor 118 is controlled through a motor control circuit 286 which, in turn, receives control signals from control cams 288 connected to the shaft of the motor 118.

General Overall Description of Scoring, Totalizing and Printing Circuitry

Referring to FIG. 10, bowling pins, not shown, on the pin spots 20 of Alley 1 and Alley 2 are each provided, for example, with permanent magnets in their bottoms. Movable across the bottoms of the pins on spots 20 are coil assemblies 290 and 292. In an actual installation, the coil assemblies 290 and 292 each comprise a plurality of aligned coils which are arranged such that as the coils sweep across the bottoms of the pins, one electrical pulse will be induced for each standing pin. The electrical pulses from the coil assemblies 290 and 292 are fed to

an alley connecting relay 294 which is adapted to apply the pulses from the coil assemblies to the detecting, registering and totalizing circuitry for either Alley 1 or Alley 2. In FIG. 10, only the circuitry for Alley 1 is shown, it being understood that the relay 294 is connected to identical circuitry for Alley 2 through lead 296, both alley circuits being connected to separate printing apparatus of the type heretofore described. In the case where bowling occurs on only one alley, the alley connecting relay 294 will connect Alley 1, for example, to its associated detecting, registering and totalizing circuitry for the entire ten frames. In the case of league play, however, the alley connecting relay 294 will alternately connect the coil assemblies 290 and 292 to one and then the other of the circuits as successive frames are played. In this manner, when one team bowls on Alley 1, for example, the pinfall results detected by the coil assembly 290 will be fed to the circuit for Alley 1. When, however, this team switches to Alley 2, the alley connecting relay will be reversed whereby the pulses from coil assembly 292 will still be fed to the same circuit; and in this manner, the pinfall results and score will be added on the same score sheet for a particular team, regardless of the alley on which they are bowling.

Each of the detecting registering and totalizing circuits comprises a master circuit including a standing pin detector 298 which subtracts the number of pulses from coil assembly 290 or 292 from ten to produce a number of electrical pulses corresponding to the number of fallen pins. That is, as the coil assembly 290 or 292 sweeps across the bottoms of the pins, a number of electrical pulses will be produced equal to the number of standing pins. These pulses must then be electrically subtracted from ten to determine the number of fallen pins. From circuit 298, a number of pulses equal to the number of fallen pins is passed to a fallen pin ball results circuit 300 which registers the number of fallen pins for each ball. This information is then fed into a ball results printing circuit 302 which energizes a selected one of the contacts 198 on the insulating boards 196 for the ball results wheels 136, 138 and 140. If it is assumed, for example, that the first ball has been rolled and that six pins have been knocked down by this first ball, then the number 6 contact on the insulating board 196 associated with gear 168 will be energized, thereby stopping the printing wheel at a position where the "6" printing character is at the top of the wheel. Thereafter, motor 118 will be energized through control circuit 286 to rotate the main drive shaft 112, thereby rotating gears 122 through one complete revolution until the cams 124 engage the brackets 126 to lift the plate 96 and the printing apparatus carried thereby upwardly into engagement with the score sheet. In this process, it will be understood that the numeral "6" is printed in the first ball results box. After the motor 118 has rotated a sufficient number of times to rotate gears 122 through one complete revolution, the control cams 228 will deenergize tthe motor through the motor control circuit 286.

Now, when the second ball is rolled, the foregoing procedure is repeated, but in this case one of the contacts 198 on the insulating board 196 associated with gear 170 will be energized to stop the printing wheel 138 at the number corresponding to the number of pins knocked down by the second ball. Thereafter, the motor 118 is again energized and the foregoing procedure repeated to print the second ball results in the second ball results box of the appropriate frame box.

The foregoing description, of course, neglected the manner in which the printing wheels are positioned beneath the correct player line and the correct frame in that player line. It will be noted that from the fallen pin ball results circuit 300, the resulting pulses pass to a frame pinfall totalizer 304 which totalizes the ball results from the first and second balls in each frame, and is thereafter reset preparatory to the rolling of the next frame. The frame pinfall totalizer 304 is connected to player relays 306, these player relays being controlled by the pushbuttons A–H shown in FIG. 2. Whenever a bowler prepares to bowl, he will initially depress the pushbutton adjacent his name on the score sheet. This then connects, through the player relays 306, the frame pinfall totalizer circuit 304 to a score totalizer 308, one of such totalizers being provided for each player. Thus, if the player whose name is adjacent the pushbutton A depresses that pushbutton, the frame pinfall totalizer 304 will be connected to the score totalizer 308–I. Similarly, when the player whose name is adjacent pushbutton B depresses his pushbutton, the player relays 306 will connect the frame pinfall totalizer 304 to score totalizer 308–II, and so on. The player relays also connect the frame pinfall totalizer 304 to strike-spare holding units 310, only two of such units being shown in FIG. 10, it being understood that one such unit is provided for each player in a game. When the player relays connect circuit 304 to the score totalizer 308–I, for example, they will simultaneously, through switch circuit 312, connect the same score totalizer 308–I to a score print circuit 314. At the same time, the player relays 306 connect circuit 304 to strike-spare holding unit 310–I and also connect circuit 304 to a frame unit 316.

Let us assume, for example, that the first player adjacent pushbutton A is bowling. Under these circumstances, he will depress the pushbutton A, thereby connecting circuit 304 to the frame unit 316 as well as to circuits 310–I and 308–I. At the same time, when the pushbutton A is depressed, it will actuate the motor 282 through player unit 318 to move carriage 78 to a position where the printing wheels are directly beneath the first player line. If the player is bowling the first frame, the frame unit 316 will actuate motor 274 through control cams 272 to move carriage 64 to a position where the printing wheels are directly beneath the first frame. After this first frame is completed, however, the frame units advance such that when the pushbutton A is again depressed, the motor 274 will be actuated to move the carriage 64 whereby the printing wheels will be under the second, rather than the first, frame. It can thus be seen that when any one of the pushbuttons A–H is depressed, the player unit 318 will energize motor 282 to move carriage 78 to the proper player line; whereas the frame units 316, having a storage unit for each player with each unit being advanced once each time a frame has been completed, will automatically move the carriage 64 to the correct frame for the particular bowler who is bowling. In this manner, it will be appreciated that the bowlers in a group or on a team need not bowl in sequence. That is, the bowler adjacent pushbutton A may, for example, bowl five successive frames, and thereafter the next bowler whose name is adjacent pushbutton B may bowl two or three frames; the bowler whose name is adjacent pushbutton C may bowl only one frame; the next bowler may bowl one or any number of frames without regard to what the other bowlers in a group or team are doing.

As was mentioned above, when any pushbutton is depressed, the player relays 306 automatically connect circuit 304 to an associated one of the strike-spare holding units 310 as well as an associated one of the score totalizing units 308. If a strike or spare is made in any frame, this is recorded in the strike-spare holding unit 310, and printing of the score is delayed until the next or successive frame. At the same time, when a player's pushbutton is depressed, the frame pinfall results are passed to his score totalizer 308 and stored therein. Thus, if a player should knock down nine pins in the first frame, nine pulses will be stored in his appropriate score totalizer 308. Then, when he bowls the next frame, the frame pinfall results of that frame will be added to his previous score in his unit 308. Assuming that no strikes or spares are made in a frame, the switch 312 will connect the appropriate score totalizer 308 to the score print circuit 314,

thereby energizing appropriate contacts 198 on the insulating boards 196 for printing wheels 130, 132 and 134 whereby these printing wheels will be rotated to the proper positions to print the accumulated score on the score sheet. If, however, a mark is made in a particular frame, the strike-spare holding unit 310 for that player will prevent the circuit 314 from printing the score in that frame. In the next or successive frame when scoring is to be achieved under the rules, however, the frame units 316 will be actuated to move the carriage 64 backwardly to the proper frame and the score print circuit 314 also actuated to print the score in that frame. It can thus be seen that the circuit of FIG. 10 provides a means whereby scoring is achieved in accordance with the rules of the American Bowling Congress.

As will be understood, proper operation of the electrical system of FIG. 10 depends upon each bowler's depressing his proper pushbutton before rolling a frame. Otherwise, if a bowler pushes the wrong button A–H, his score, for that frame, will be credited to another bowler in the group. Although the arrow 212 shown in FIG. 2 should substantially eliminate this possibility, further insurance can be achieved by use of the arrangement shown in FIGS. 11, 12 and 13.

With reference to FIGS. 11–13, there may be provided over the pushbuttons A–H a stamped cover 324 screwed or otherwise securely fastened to the top plate 40 of console 38. Punched into the cover 324 above the respective pushbuttons A–H are holes 326, each representing the letter corresponding to the pushbutton beneath it. By providing keys 328 (FIG. 13) which will fit into only respective ones of the holes 326, and by giving each player the key corresponding to his correct pushbutton, any possibility of a player's depressing the wrong pushbuttons is entirely eliminated. That is, if player A, for example, is given the key shown in FIG. 13, that key will fit into the proper hole 326 only and no other. Similarly, the other bowlers will have keys which will fit only the correct hole.

For a scoring machine designed as a single unit to service two alleys, two sets of keys will be provided, together with a cover 324 for each set of pushbuttons on the console 38. In this case, one set of keys and holes in one plate 324 are preferably larger than those of the other to prevent interchangeability of keys. Also, the two sets will preferably be of different colors to match different colored plates 324.

Relationship of Master Circuit and Player Units

The circuitry embodied in the blocks 294, 316, 318, 310–I, 310–II, 306, 308–I, 308–II, 312 and 314 of FIG. 10 is shown in detail in FIGS. 14A–14B. Although circuitry for only two players is shown, it will be understood that the number may be increased as desired. Likewise, the circuitry embodied in the blocks 286, 298, 300, 304 and 302 of FIG. 10 is shown in detail in FIGS. 15A–15F. In FIGS. 14A–14D and in FIGS. 15A–15F, there are two master cables P and M. The cable P serves to connect circuit components in the player units of FIGS. 14A–14D to components in the master circuit of FIGS. 15A–15F. The cable M, on the other hand, interconnects only elements of the master circuit shown in FIGS. 15A–15F. Thus, any lead which goes from a master circuit element into cable M will go to another master circuit component; whereas leads which go into cable P will travel from the player units of FIGS. 14A–14D to the master circuit of FIGS. 15A–15F, or vice versa. Furthermore, it should be understood that each time a ball is rolled, any of the master circuit components may come into play regardless of which bowler delivers the ball. In the player units of FIGS. 14A–14D, however, each player is provided with certain circuitry which is connected to the master circuit when, and only when, that particular bowler is bowling. That is, a particular bowler's circuitry in the player units is connected to the master circuit only when his player pushbutton is depressed to close his player relay, hereinafter described, which acts to connect that player's unit to the master circuit. In this manner, the pinfall results of each ball, strikes, spares, doubles, and other pertinent information for each bowler is fed to his player unit to be stored and/or added to this previous score preparatory to a score printing operation.

Player Pushbuttons and Player Line Unit

With reference to FIG. 14A, the first two player pushbuttons A and B are shown. Each player pushbutton is provided with two pairs of normally open contacts, and the two pushbuttons are mechanically interconnected as shown by the dotted line such that when any player pushbutton is depressed, it will automatically release the other pushbuttons with the result that only one pushbutton is depressed at any one time. Furthermore, means, not shown, are provided to maintain any pushbutton depressed after it is initially pushed by a player. Before a game is started, a player selector switch PS is adjusted for the number of players participating in the game. It will be noted that the selector swich PS is provided with two wiper brushes 902 and 904 mechanically interconnected as at 900 such that the one wiper brush will turn with the other. Wiper brush 902 has a single arm thereon, while brush 904 has a plurality of such arms with the first arm of brush 904 having the same angular position as the single arm on brush 902. Each of the wiper brushes is provided with a plurality of contacts, the contacts for the one wiper brush being connected through leads 690 and 691, for example, to normally open contacts on player pushbuttons A and B, respectively, these pushbuttons being those shown in FIGS. 2, 10, 11 and 12. The contacts on the other wiper brush of the player selector switch PS, on the other hand, are connected through leads 745 and 746 to normally open contacts on cam switches for cams 280B and 280C, respectively, for the player travel motor 282 shown in FIG. 5. The other side of one of the normally open contacts on player pushbutton A is connected through lead 596 to the normally open contacts on a cam switch for cam 280A, this cam also being on the shaft of player travel motor 282. In a similar manner, one of the normally open contacts on player pushbutton B is connected through lead 697 to a pair of normally closed contacts on the cam switch for cam 280B. The normally closed contacts on the cam swich for cam 280C are connected to pushbutton C, not shown in FIG. 14A. One of the wiper brushes 902 on the player selector switch PS is connected directly to a source of positive voltage, marked +; whereas the other wiper brush 904 is connected to this same source of positive voltage through the normally closed contacts of relay 638. As shown, the relay 638 has two windings thereon, one of which will move the movable contact 906 in one direction; whereas the other, when energized, will move it in the opposite direction. One side of each of the windings on relay 638 is connected to ground while the other side of the one winding is connected through lead 512 to a cam switch on cam 608–C (FIG. 15B) and thence to a positive source of voltage through normally open contacts on relay 621. As will be seen, relay 621 is pulsed when each ball in the game is delivered. Consequently, relay 638 will be pulled in and locked upon delivery of the first ball in each frame. The other coil or winding on relay 638 is connected through lead 431 and through the normally closed contacts of relay 613 of the master circuit (FIG. 15D) to lead 833 connected to a score motor cam switch 984–14 (FIG. 15E), hereinafter described. The relay 638, as well as the other relays hereinafter described which have two coils thereon and which are marked "N" and "S" at their opposite ends, are of the magnetic type, meaning that once the relay is pulled in one direction or the other, it will stay in that position until it is positively energized through the other winding to reverse its position. It will be noted

that contacts on relay 638 are such that when the coil connected to lead 725 is energized, the contact 906 will make with contact 908 before contact is broken between contacts 908 and 910. The contact 906 is connected through lead 450 to a set of normally open contacts on each of the player relays 241A and 241B. As will be understood, when contacts 908 and 910 break upon delivery of the first ball of a frame and consequent energization of relay 638, the circuit to wiper brush 904 is broken, thereby preventing a second bowler from connecting into the circuit before the bowler who is bowling has completed his frame. At the same time, when contacts 906 and 908 make, a hold circuit is provided for the appropriate player relay 641A or 641B through lead 450, normally open contacts on the appropriate relay which are now closed since the relay has been initially energized by closure of a player pushbutton, and holding coil 911H. Thus, the appropriate relay 641A or 641B will remain energized until relay 638 is pulled out by energization of lead 431 which occurs at the completion of a frame. When the appropriate relay 641A or 641B is thus held in closed position when a frame is started, the corresponding player push-button A or B is released by a solenoid 974 connected through lead 433 to a contact on level 608–L1 of stepping unit 608 (FIG. 15B) in the master circuit. The unit 608 will be advanced after delivery of the first ball in a frame to energize lead 433 and release the pushbutton, the lead 433 being energized at this point through lead 408 (FIG. 15B) connected to the wiper brush of level 608–L1 and contacts on pulser relay 621.

Magnetic Lock Relays—Power Failure Safety Feature

As was mentioned above, relay 638 as well as the other relays hereinafter described marked "N" and "S" at their opposite ends will stay in one position or the other when neither of their windings are energized. This is effected by virtue of the fact that in all of these relays a permanent magnet or the like is provided having its opposite poles at the opposite ends of the relay armature. In the description which follows, the coil on each of these relays which acts to reverse the positions of the contacts shown is called the "pull-in" coil; whereas, the other coil which pulls the contacts into the positions shown from their reversed positions is called the "reset" or "pull-out" coil.

As will be understood, the various circuit components hereinafter described electrically store information regarding strikes, spares, doubles, the first or second ball rolled in a frame as well as other information as the bowling game progresses. If relays were employed for this purpose which would "drop out" in the absence of energizing current, much information regarding the game would be lost in the event of a power failure such as that which might occur in an electrical storm, the result being that a game would not be scored correctly if such a power failure occurred while it was being played. The magnetic lock relays of the type described above prevent such a condition. Furthermore, it will be seen that stepping units are employed in the circuitry which rotate in one direction only and must be positively driven in that one direction to "home out" and reset the circuit at the completion of various cycles of operation. Thus, no units are "homed out" by coil springs or the like with the result that the reliability of the equipment is greatly enhanced.

Player Unit and Player Travel Motor

Let us assume, for example, that two bowlers are to play on a single alley. Under these circumstances, the player selector switch PS will be advanced such that its wiper brushes 902 and 904 are in the positions shown. Now, when player A prepares to bowl, he will depress his pushbutton A, thereby energizing winding 911 on player relay 641A to close all of the normally open contacts thereon. Similarly, if the player pushbutton B were depressed, the relay 641B would be energized, and so on. It will be noted that the cams 280A, 280B and 280C are provided with notches in their peripheries spaced apart by a predetermined number of degrees. The player travel motor 282 is provided with two control relays 622 and 623. When relay 622 is energized to close its normally open contacts, the motor 282 will be rotated in a forward direction so as to move the printing wheels downwardly as viewed in FIG. 2. When, however, the relay 623 is energized to close its normally open contacts, the direction of rotation of the player motor 282 will be reversed such that the printing wheels will be moved upwardly as viewed in FIG. 2.

With the positions of the cams 280A–280C as shown, the printing wheels will be directly under the player line A. Thus, when pushbutton A is depressed, the player travel motor 282 will not be energized since the circuit to both of the relays 623 and 622 is broken through the contacts on cam 280A. If, however, it is assumed that the player pushbutton B is now depressed, a circuit will be completed to the forward relay 622 through lead 505, the normally closed contacts on relay 612, lead 464, the normally closed contacts on the cam switch for cam 280B and lead 697 to the pushbutton switch B, the other side of the contacts on pushbutton B being connected through lead 691 and wiper brush 904 to a source of positive voltage through contacts 908 and 910. Thus, the player travel motor 282 will be rotated in a forward direction to lower the printing wheels as shown in FIG. 2 until the notch in cam 280B is reached to break the circuit between leads 697 and 464, thereby stopping the player travel motor with the printing wheels directly beneath the second player line B.

Assuming, now, that the printing wheels are beneath the second player line B and the pushbutton A is depressed, the reverse travel relay 623 will be energized in the following manner: When the player pushbutton A is depressed a circuit will be completed through lead 696 and the cam switch on cam 280A, which is now closed, to lead 464, thereby energizing the forward relay 622. Consequently, the player travel motor 282 will rotate in a forward direction until a point is reached where the notch in cam 280C closes the lower contacts of its cam switch to connect lead 746 to lead 411, thereby energizing the relay 612 to reverse the positions of its contacts. When the contacts on relay 612 are thus reversed, the reverse relay 623 will be energized through lead 464, the switch on cam 280A, which is now closed, and lead 696, thereby causing the player travel motor 282 to reverse its direction of rotation and move the printing wheels upwardly as shown in FIG. 2. This upward motion of the printing wheels will continue until the notch in cam 280A reaches the position shown in FIG. 14A to break the circuit between leads 696 and 464. At this position, then, the printing wheels will again be beneath the player line A.

It can thus be seen that if any player pushbutton is depressed and the printing wheels are above the player line for that pushbutton, the forward relay 622 will be immediately energized to cause the player travel motor 282 to move the printing wheels downwardly. When, however, a player pushbutton is depressed and the printing wheels are below the correct player line, the player travel motor will first be energized to rotate in a forward direction until it reaches the player line following the last player who is bowling; whereupon relay 612 will be energized to energize the reverse relay 623 and cause the player travel motor 282 to move the printing wheels upwardly until they stop at the correct player line. The relay 612 is of the magnetic lock type described above and will stay in one position or the other until it is energized oppositely. Also included in the player travel circuit are two limit switches 914 and 916. These limit switches are provided to automatically reverse the posi-

tions of the contacts on relay 612 and reverse the direction of movement of the player travel motor 282 whenever the opposite extreme limits of travel are reached by the carriage 78 (FIG. 3) on which the printing wheels are carried. That is, the limit switches 914 and 916 are positioned on the carriage 64 (FIG. 3) at opposite ends of the path of travel of the carriage 78. From the foregoing it can be seen that when any one of the player pushbuttons is depressed, the player travel motor 282 will automatically position the printing wheels beneath the corresponding player line, while the limit switches 914 and 916 prevent the carriage 78 from running off its tracks 70 and 72.

Frame Unit and Frame Travel Motor

Whenever any one of the player relays 641A, 641B, and so on is energized, all of its normally open contacts are closed. Let us assume, for example, that the pushbutton A is depressed and that the relay 641A is energized to close all of its contacts. When this occurs, lead 431 (FIG. 14A) which is connected to a switch on one of the score motor cams of the master circuit, hereinafter described, will be connected through lead 432 to the motor magnet (FIG. 14B) for frame stepping unit 602A. The motor magnet on frame unit 602A is connected to the wiper brushes on a plurality of contact levels 602–A–L1 to 602–A–L6. Although not shown herein, the motor magnet for unit 602A, as well as the other motor magnets hereinafter described, are actually connected to a pawl on a ratchet wheel, the ratchet wheel being connected to the various contact levels. Thus, each time the motor magnet is energized by a pulse, the ratchet will advance the wiper brushes on the various contact levels from one contact point to the next. Also provided on the unit 602A are normally closed contacts 602A–K which will open each time the motor magnet is pulsed or energized. The ratchet for the motor magnet is then connected through a cam 602A–C to various contact levels, the arrangement being such that the cam will be rotated in steps as the motor magnet is pulsed. Provided on the cam 602A–C are two sets of normally closed contacts and one set of normally open contacts, the normally open contacts being connected through contacts 602A–K to lead 432 and to a second lead 786 which is connected through the cable P to the master circuit in a manner hereinafter described.

Each time the player pushbutton A, for example, is depressed and the player relay 641A energized, the lead 432 on the motor magnet for unit 602A will be connected to lead 431 connected through cable P to the master circuit. As will hereinafter be seen, the lead 431 is energized to pulse the motor magnet for unit 602A once and advance the wiper brushes on the six contact levels after a player completes a frame. The same applies to the frame unit 602B. That is, it will be pulsed once to advance wiper brushes on its various contact levels each time the player corresponding to line B completes a frame.

In FIG. 14B the frame travel motor 274 is shown as being connected through a gear reducer 918 to the frame travel cams 272–1 to 272–10. The frame travel motor 274 has forward and reverse windings thereon as shown, the forward winding being controlled by a relay 627 and the reverse travel being controlled by a relay 626. The ten cams 272–1 to 272–10 are each provided with reduced diameter portions which extend through slightly over 180° of the circumference of the cam, and enlarged diameter portions that extend through slightly under 180° of the circumference of the cam. On one side of each cam 272–1 to 272–10 is a contact connected through lead 760 to the forward travel relay 627; whereas the other side of each cam is provided with a contact connected through a common lead 757 to the reverse travel relay 626. The contacts which are to the right of each cam are also connected through leads 681, 682, 683, 684, 685, 686, 687, 688 and 689 to the nine contact points on levels 602–A–L1 and 602–B–L1 as well as the corresponding levels, not shown, for each player in the game. In a similar manner, contacts to the left of cams 272–1 to 272–9 are connected through leads 702, 703, 704, 705, 706, 707, 708, 709 and 710 to contact points on the levels 602–A–L2, 602–A–L3, 602–A–L4 and the corresponding levels 602–B–L2, 602–B–L3 and 602–B–L4 for unit 602B.

As shown, alternate contacts on levels 602–A–L5 and 602–B–L5 are interconnected, and the respective interconnected sets of contacts are connected through leads 713 and 761 and the cable P to the master circuit, hereinafter described. As will be seen, the levels 602–A–L5 and 602–B–L5 are employed for league play wherein the bowlers alternate from one alley to the other during successive frames. The levels 602–A–L5 and 602–B–L5 perform the function of alternately energizing leads 713 and 761 for this purpose. That is, when lead 713 is energized, it will be seen that the pinfall results from one alley will be applied to the scoring and totalizing units for a particular player; whereas in the next frame only the pinfall results from the other alley would be applied to that particular player's scoring and totalizing units. In this respect, it is important to remember that the brushes on levels 602–A–L5 and 602–B–L5 are energized through leads 793 and 800, respectively, only when the equipment is operating on league play.

The only purpose of levels 602–A–L6 and 602–B–L6 is to provide a signal on lead 403 during the tenth frame. As is known, in the tenth frame a bonus ball may be allowed, meaning that special provision must be made for entering the ball results in this, the last frame. This is accomplished, as will be seen, by energizing the lead 403 in the tenth frame to actuate suitable circuitry for accommodating the bonus balls in the tenth frame.

During normal frame play, and in the absence of any strikes or spares, the leads 802 and 794 will be energized for unit 602A; and, similarly, the leads 796 and 801 will be energized for normal frame play when bowler A is bowling. The cams 272–1 to 272–10 are such that when the printing wheels are in the seventh frame, for example, the cam 272–7 will be positioned such that the contacts on its opposite sides are both open. At all other times, however, one of the contacts on one side of the cam 272–7 will be closed while that on the opposite side will be open. Furthermore, when the printing wheels are to the left of the seventh frame as viewed in FIG. 2, the contacts to the left of cam 272–7 will be open while those to the right will be closed. Similarly, when the printing wheels are to the right of the seventh frame, the contacts to the right of cam 272–7 will be open while those to the left will be closed.

As was mentioned above, each time a player completes his frame, his associated motor magnet 602A, for example, will be energized to advance the wiper brushes on levels 602–A–L1 to 602–A–L6. Let us assume, for example, that a bowler has rolled three frames and is preparing to bowl the fourth frame. At this point, the wiper brush on levels 602–A–L1 to 602–A–L4 will be on contact 920. Let us further assume that the printing wheels are in the third frame. Under these circumstances, the angular position of cam 272–4 will be such that the contacts to the right of it are closed while those to the left are open. Since lead 802 is energized at this time, a circuit will be completed through lead 683, the contacts to the right of cam 272–4, and lead 760 to the forward relay 627 to cause the frame travel motor 274 to move the printing wheels from the third to the fourth frame, at which point the contacts on both sides of the cam 272–4 will be open and the frame travel motor 274 will stop.

On the other hand, let us assume that when the player pushbutton was depressed preparatory to the bowler's bowling his fourth frame, the printing wheels are in the ninth frame. Under these circumstances, the contacts to

the right of cam 272–4 will be open; whereas those to the left will be closed. Consequently, the forward relay 627 can no longer be energized from lead 802; however the reverse relay 626 will be energized from lead 794 through lead 705 and the contacts to the left of cam 272–4, which are now closed, and lead 757. Under the circumstances just described, the frame travel motor 274 will be caused to rotate in a reverse direction to move the printing wheels to the fourth frame, whereupon the contacts on both sides of the cam 272–4 will be open so that the frame travel motor will stop with the printing wheels directly beneath the fourth frame. Thus, whenever a pushbutton is depressed, two things happen. First, the printing wheels on carriage 78 are moved by player travel motor 282 to the correct player line. Second, the printing wheels are simultaneously moved by frame travel motor 274 on carriage 64 to the frame box corresponding to that frame which the bowler is about to bowl. As will be understood, the position of the printing wheels is dependent upon the position of the brushes on the contact levels for each player unit 602A, 602B, etc., and this position is, in turn, controlled by the number of frames which the bowler has previously bowled. Furthermore— and this is important—since each one of the player units 602A, 602B, etc., is controlled independently of the other player units, the bowlers need not bowl in succession as was the case in prior art systems. That is, the bowler corresponding to player unit 602A could conceivably bowl seven successive frames by himself before the bowler corresponding to unit 602B bowled a single frame. The bowler corresponding to played line B could then bowl, say, three or four frames by himself without regard to player A. This is particularly advantageous in the case of a bowler on a team who arrives late, enabling him to "catch up" to the other bowlers without regard to the frames which the other bowlers are bowling in at the time he arrives.

The foregoing procedure applies for normal frame play with no strikes or spares made in previous frames. As is known, when a strike or a spare is made, scoring is delayed until the first ball in the next frame is rolled in the case of a spare, and delayed until both balls are rolled in the next frame in the case of a strike. In a somewhat similar manner, if two strikes are made in succession, scoring is delayed until the second ball has been rolled after the first strike. In one case, the bowler will be bowling one frame ahead of the frame where the score is to be entered and in the other case he will be bowling two frames ahead of the frame in which the score is to be entered. Accordingly, some means must be provided for traversing the printing wheels backwardly for one or two frames, respectively, depending upon whether a strike or spare is made, or two strikes are made in succession. For this purpose, the levels 602–A–L2, 602–B–L2 and 602–A–L3, 602–B–L3 are provided. Let us assume, for example, that we are in the fourth frame as in the example given above and that the wiper brushes on levels 602–A–L2 and 602–A–L3 are on contacts 920. If a spare was made in the previous frame (i.e., the third frame in this case), lead 791 will be energized as soon as the bowler depresses his pushbutton for the fourth frame. As will be seen, the lead 791 is energized through relay 641A, lead 485, cable P and mark spare relay 615 (FIG. 15D) in the master circuit, hereinafter described, this relay being energized at this time since a spare was made in the previous frame. Consequently, since contact 920 on level 602–A–L2 is connected to lead 704, and since this lead 704 is connected to the contacts to the left of cam 272–3, the printing wheels will be caused to stop at the third frame. When the first ball in the fourth frame is rolled, however, the relay 629 (FIG. 15E), hereinafter described, is energized to print the results of the first ball in the fourth frame. Energization of the relay 629 deenergizes lead 791 and energizes lead 802, thereby energizing lead 683 to move the printing wheels to the fourth frame where the ball results are printed. Thereafter, the relay 629 is deenergized whereby the lead 791 is again energized to move the printing wheels back to the third frame where the score is printed. When the second ball in the fourth frame is rolled, relay 629 is again energized to break the circuit to lead 791 and energize lead 802 whereby the printing wheels move to the fourth frame. Upon rolling of the second ball, however, lead 802 remains energized after delivery of the second ball so that lead 683 also remains energized to print the score in the fourth frame, assuming that no marks had been made in this, the fourth frame.

If a strike is made, the situation is the same as before, except that the lead 791 does not become energized until the second ball is delivered so that the printing wheels move back to the third frame only after the second ball in the fourth frame is delivered to print the score. After the score in the third frame is printed, the lead 791 is deenergized, the lead 802 is energized and the printing wheels move to the fourth frame where the score is printed, assuming that no marks had been made in the fourth frame.

Let us assume, now, that the wiper brushes are again on contacts 920 and that two successive strikes have been made in the second and third frames. Under these circumstances, and under the rules of the American Bowling Congress, the score is not entered in the second frame until the next two balls have been delivered. Consequently, the lead 792 will be energized through the mark doubles relay 618 (FIG. 15D) after two balls are delivered, and since contact 920 on level 602–A–L3 is connected to lead 703, the printing wheels will be moved backwardly to the second frame to print the score in that frame. It can thus be seen that the frame units shown in FIG. 14B will move the printing wheels to the proper frame according to the proper rules of the American Bowling Congress.

Player Score Storage and Printing Units

Referring now to FIGS. 14C and 14D, the player score storage and printing units for players A and B are shown. Each player score storage assembly consists of two stepping units. Thus, player A is provided with a units stepping arrangement identified as 604A and player B is provided with a similar units stepping assembly identified as 604B. Each unit assembly 604A and 604B comprises a motor magnet connected through a ratchet to a cam 604A–C or 604B–C, respectively. Furthermore, each time the motor magnet for unit 604A or 604B is energized, it will open normally closed contacts 604A–K or 604B–K, respectively. The unit 604A, for example, is provided with two contact levels 604–A–L1 and 604–A–L2. Whenever pins are knocked down by a ball, circuitry in the master circuit, hereinafter described, will supply pulses through either relay 641A or 641B to the motor magnet for unit 604A or unit 604B, respectively. The pulses for unit 604A are supplied through lead 625 which, in turn, is connected through relay 641A to lead 449, this lead being the master units pulse line from the master circuit hereinafter described. In a similar manner, the pulses for unit 604B are applied through lead 626 which is also adapted to be connected to the master units pulse line 449 through relay 641B.

Let us assume, for example, that the player pushbutton A has been depressed and that relay 641A is energized. Under these circumstances, lead 625 will be connected to the master units pulse line 449. Each time a pulse is received on lead 625', the wiper brush on level 604–A–L1 will be advanced. For example, if nine pins have been knocked down in the first frame of a game, the wiper brush on level 604–A–L1 will have been advanced to the ninth contact point on level 604–A–L1, thereby connecting the wiper brush to lead 616 which, in turn, is connected to the No. 9 contact point on the insulating board 196U for the units printing wheel 134 (FIG. 3). Thereafter, when the printer drive motor 118 is rotated, the units printing wheel 134 will stop at the No. 9 position when the wiper brush

204U reaches the No. 9 contact and energizes solenoid 186U.

If, in the second frame three additional pins are knocked down, the wiper brush on level 604–A–L1 will be advanced three times, meaning that one of the arms on the wiper brush will have advanced to the No. 2 contact, this contact being connected to lead 624 which, in turn, is connected to the second contact point on the insulating board 196U. At the same time that the wiper brush on contact level 604–A–L1 was being advanced, the wiper brush on contact level 604–A–L2 was advanced also. When this wiper brush reached the ninth contact point, it energized lead 609 to advance the tens unit 605A once. Thus, with unit 605A advanced once, the wiper brush on level 605–A–L1 is connected to lead 678 which, in turn, is connected to the No. 1 contact point on the insulating board 196T for tens printing wheel 132. The result is that a number 1 will appear at the top of the tens printing wheel during a printing operation, while the number 2 will appear on the units printing wheel for a total of twelve, this corresponding to the number of pins knocked down which was nine for the first frame plus three for the second frame. Let us assume further that with the second ball in the second frame six additional pins are knocked down, meaning that the wiper brush on level 604–A–L1 advances to the eighth contact point, thereby energizing the lead 617 which is connected to the No. 8 contact on insulating board 196U. The total printed by the printing wheels will now be eighteen, the numeral 1 still persisting on the tens printing wheel 132 and the units printing wheel 134 having been advanced to eight.

Thus, the tens unit 605A is advanced once each time the units unit 604A is advanced through its ninth contact. This process will continue until the tens unit 605A has been pulsed ten times, meaning that the total number of pins knocked down is one hundred. It will be noted that on the unit 605A are contact levels 605–A–L2, 605–A–L3 and 605–A–L4 in addition to level 605–A–L1. Whereas the contact level 605–A–L1 has three wiper brushes thereon spaced 120° apart, the other contact levels have only one wiper brush thereon. Furthermore, the wiper brush on level 605–A–L2 is spaced 120° in one direction and that on level 605–A–L3 is spaced 120° in the opposite direction from the brush on level 605–A–L4. The result is that by the time unit 605A has been pulsed ten times, the wiper brush on level 605–A–L3 will reach its last contact point where it energizes lead 452, thereby energizing the No. 1 contact point on the hundreds insulating board 196H to stop the hundreds printing wheel 130 at the No. 1 position. If one hundred, eleven pins have been knocked down, the wiper brush on level 605–A–L4 will be on its second contact point which is interconnected with the next successive eight contact points, all of these eight contact points being connected to the lead 452 to energize the No. 1 contact on insulating board 196H for the hundreds printing wheel. Thus, the No. 1 contact on board 196H will be energized at this time notwithstanding the fact that the wiper brush on level 605–A–L3 was disconnected from lead 452 when the count changed from one hundred, ten to one hundred, eleven. When the 200th pin is knocked down, the wiper brush on level 605–A–L4 will have advanced to the tenth contact point, thereby energizing lead 451, which is connected to the second contact point on the insulating board 196H, while deenergizing the first contact point on the same insulating board. When lead 451 is energized, it also pulls in the magnetic lock relay 649 to close its normally open contacts, thereby connecting lead 662 to lead 453 which, in turn, is connected to the No. 3 contact on insulating board 196H. At this time, however, lead 662 is not energized so that the No. 3 contact on board 196H is not energized. When the 211th pin is knocked down, the wiper brush on level 605–A–L2 will move to the second contact point, and since the second to the ninth contact points on this level are strapped together and connected to lead 451, the No. 2 contact on the insulating board 196H will remain energized, from the 211th to the 299th pin notwithstanding the fact that the wiper brush on level 605–A–L4 is no longer connected to lead 451. Finally, if and when the 300th pin is knocked down in the game, the wiper brush on level 605–A–L2 will contact lead 662, thereby energizing lead 453 connected to the No. 3 contact point on insulating board 196H while the No. 1 and No. 2 contact points are deenergized.

It can thus be seen that as pins are knocked down in a bowling game, they are totalized in the circuits shown in FIGS. 14C and 14D, these circuits serving to energize selected ones of the contact points on insulating boards 196U, 196T and 196H to print the proper numerical score. When the game is completed after the tenth frame, means, hereinafter described, are provided for returning the units 604A and 605A to their initial or home positions. Each time the score motor of the master circuit, hereinafter described, cycles, the second or release coil on relay 649 is energized through lead 428 to open its contacts, this relay being again energized each time a player unit is activated and is on at least two hundred pins preparatory to the scoring of a potential three hundred game. Although the storage units 604B and 605B for the second player have not been described in detail, it will be understood that they operate in exactly the same manner as the units 604A and 604B already described, the leads from the units unit 604B being connected to leads 615–625′ which are connected to the contact points on insulating board 196U; the leads on tens unit 605B being connected to leads 669–678 which are connected to the contact points on insulating board 196T, and also to leads 451, 452 and 453 which are connected to the three contact points on insulating board 196H. As will be understood, the leads 615–625′, 669–678 and 451–453 will also be connected to the other player units, the number of which depends upon the number of players bowling in a particular game.

Naturally, only one of the player's storage units will be energized at any one time to, in turn, energize contact points on the boards 196U, 196T and 196H. These units are energized by energizing their wiper brushes through appropriate leads connected to an associated one of the player relays 641A or 641B. Thus, the wiper brushes on units 604A and 605A are connected through leads 625, 603, 655, 631, 649 and 643 to lead 449 or lead 457 which, in turn, is connected to a source of positive voltage through the normally closed contacts of a result print relay 629, hereinafter described in the master circuit. In a similar manner, the wiper brushes on units 604B and 605B are adapted to be connected through leads 626, 604, 656, 650, 644 and 632 to the lead 449 or 457, when the player relay 641B is energized.

Strike-Spare Holding Units

The player storage units of FIGS. 14A–14D also include strike-spare holding units 610A and 610B, one for each player in a game. The manner in which the strike-spare holding units are controlled will hereinafter be described more fully in detail with respect to the master circuit; however for purposes of explaining the apparatus shown in FIG. 14A it will be sufficient to state that when a spare is made in a frame, one of the units 610A or 610B, depending upon which player relay 641A or 641B is energized, will be pulsed once to rotate all of the cams 610–A–1, 610–A–2, 610–A–3 or 610–B–1, 610–B–2 and 610–B–3. When one pulse is received by unit 610A, for example, the cam switch on cam 610–A–3 will be reversed; when a strike is made and two pulses are received by the unit 610A, the cam switch on cam 610–A–2 will be reversed from the position shown; and when four pulses are received by the unit 610A in response to two

successive strikes or a double, the cam switch on cam 610–A–1 will be reversed.

League Play Control Relay

There is one other circuit component which should be described in FIG. 14A, and this is the league play control relay 617. Relay 617 is energized by means of closure of league play switch 922, and there is one such switch 922 and one relay 617 for two alleys; whereas each alley includes separate circuitry of the type already described as well as a separate master circuit. When it is not desired to score the game in league play, the switch 922 will be open whereby the relay 617 will be deenergized, thereby connecting the lead 713 to lead 775. Lead 713, in turn, energizes the alley control relay 619 in the master circuit, hereinafter described, with the result that the master circuit and storage circuits of one alley will be consistently connected to the pinfall detector, hereinafter described, of that one alley only. When, however, the relay 617 is energized by closure of switch 922, the lead 775 will be connected to lead 520 which, in turn, is adapted to be connected through normally open contacts on all of the player relays 641A, 641B, and so on, to lead 793 on levels 602–L5 of frame storage unit 602A or to lead 800 on frame storage unit 602B. In a similar manner, closure of relay 617 makes similar connections in the scoring, totalizing and printing circuitry for the other alley.

Standing Pin Detector

Referring now to FIGS. 15A–15F, and particularly to FIG. 15A, there is shown, at the left end thereof, four electromagnetic coils 926, 927, 928 and 929. A set of such coils is carried on each of the bars 290 and 292 shown in FIG. 10 and arranged to sweep transversely across the tops of the pins on each alley. In FIG. 15A, the means for sweeping the coils across the tops of the pins is indicated as a motor 930; however, for a full and detailed description of the operation of the detecting means and the manner in which the coils 926–929 are swept across the tops of the pins, reference may be had to our copending application Serial No. 134,809, filed September 7, 1961 and entitled "Automatic Pinfall Detecting Apparatus for Bowling Game."

For purposes of the present description, it will be sufficient to state that when the motor 930 rotates, the coils 926–929 will be moved transversely across the tops of the pins shown in FIG. 10. The coils 926–929 are arranged in end-to-end relationship along the length of each of the bars 290 and 292, with the coil 926 covering a Zone I which sweeps across only the No. 1 pin in the triangular configuration. Coil 927 will sweep across Zone II covering the second row of pins designated as Nos. 2 and 3; coil 928 will sweep across Zone III covering the third row of pins designated Nos. 4, 5 and 6, and coil 929 will sweep across Zone IV covering the last row of pins designated as Nos. 7, 8, 9 and 10. Embedded in one end of each pin, either the top or bottom, is a small permanent magnet having north and south poles spaced along vertical axes and adapted to produce magnetic fields through which one of the coils 926–929 will cut in passing from one side of the alley to the other. Thus, assuming that the speed of bar 290 or 292 is above a predetermined value as it sweeps across the alley, a momentary electrical current will be induced in each of the coils 926–927 as it passes over an end of a standing pin. These electrical current impulses are used in circuitry, hereinafter described, to produce a number of electrical pulses or signals corresponding to the number of pins knocked down after each ball in a bowling game is delivered.

As will be understood, it is necessary to produce a single and separate current pulse in one of the coils 926–929 for each standing pin in the triangular configuration. The necessity for four coils thus becomes apparent. That is, it can be seen from FIG. 10 that the No. 1 pin is directly in front of the No. 5 pin. Similarly, the No. 2 pin is directly in front of the No. 8 pin, and the No. 3 pin is directly in front of the No. 9 pin. If a single coil were swept across the tops of the pins, a single current impulse would be induced in the coil for both of the pins numbered 2 and 8, both of the pins numbered 1 and 5, and both of the pins numbered 3 and 9, meaning that if all pins were standing, only seven current impulses would be produced by the single coil; whereas, it is desired to produce ten impulses. With the arrangement shown in FIG. 15A, however, no pins under any one coil are aligned with other pins in that same zone so that the cumulative number of impulses produced by the four coils will always be ten, assuming that all of the pins are left standing. Of course, if certain ones of the pins are knocked down after a ball is rolled, only the cumulative number of impulses corresponding to the number of pins left standing will be produced by the coils. Furthermore, even though certain ones of the pins may slide on the deck to positions where they are directly in front of other pins, the correct number of impulses will always be produced. This is more fully explained in our copending application Serial No. 134,809, mentioned above.

Each of the coils 926, 927, 928 and 929 is connected to a corresponding amplifying circuit 931, 932, 933 and 934, respectively. Since all of the circuits 931–934 are identical, only circuit 931, enclosed by broken lines, will be described in detail. Across winding 926 are a capacitor 935 and a resistor 936 connected in parallel. One end of the winding 926 is connected to the base 937 of a junction transistor 938, while the other end of the same winding is connected to the emitter 939 of the transistor. Connected between the base 937 of transistor 938 and its collector 940 is a resistor 941. Driving potential is provided for the transistor 938 by a voltage doubler rectifier including a pair of unidirectional current devices 942 and 943 and capacitors 944 and 945. The junction between capacitors 944 and 945 is connected to one side of a first secondary winding 946 on input transformer 947, while the other side of this secondary winding 946 is connected to the anode of diode 942 as well as the cathode of diode 943. The primary winding 948 of transformer 947 is adapted for connection to a source of alternating current voltage, not shown, at terminals 949 and 950. The direct current voltage for transistor 938 is derived, as shown, by means of a movable tap on resistor 951 connected in parallel with the capacitors 944 and 945.

The collector 940 of transistor 938 is connected to the control grid 952 of a thyratron gas discharge tube 953 having a suppressor grid 954 connected to its cathode through resistor 955. The resistor 955 is also connected to the cathode of unidirectional current device 943 in the voltage doubler rectifier whereby a bias voltage will be supplied to the suppressor grid 954. Connecting the cathode 956 and anode 957 of thyratron 953 is a circuit including the secondary winding 958 of transformer 947 and the primary winding 959 of an output transformer 960. The circuit is completed by a heater element for the thyratron 953 which is connected across two terminals of the secondary winding 946 on transformer 947.

With this arrangement, whenever a current impulse is induced in winding 926 upon passage of the winding through the magnetic field of a standing pin, transistor 938 will conduct to raise the voltage on the control grid 952 of thyratron 953 to the firing level. Thus, the thyratron will conduct to produce a pulse across the primary winding 959 of output transformer 960. This pulse is applied via the secondary winding 961 of the output transformer 960 to a relay 962 having a pair of normally open contacts 963. In a similar manner, the circuits 932, 933 and 934 for windings 927, 928 and 929, respectively, are provided with relays 964, 965 and 966. Each of the relays 964, 965 and 966 is provided with a pair of normally open contacts 967, 968 and 969, respectively. Thus, for example, if one pin is left standing in Zone I

covered by coil 926, relay 962 will be energized once to closed contacts 963 once; if one pin is left standing in Zone II covered by coil 927, relay 964 will be energized once to close contacts 967 once; if two pins are left standing in Zone III covered by coil 928, relay 965 will be energized twice to close contacts 968 twice; and, finally, if three pins are left standing in Zone IV covered by coil 929, relay 966 will be energized three times to close its contacts 969 three times.

Alley Connecting Relays

It will be noted in FIG. 15A that the circuit includes two alley connecting relays 619 and 629. The energizing coil for relay 619 is connected through lead 713 to a pair of normally closed contacts on league play control relay 617 (FIG. 14A). After passing through the normally closed contacts on relay 617, lead 713 is connected to lead 775 which, in turn, is adapted to be connected to a source of positive voltage through normally open contacts on any one of the player relays 641A, 641B, and so on. The lead 713 is also connected to alternate contacts on levels 602–A–L5 and 602–B–L5 (FIG. 14B), the wiper brushes for these levels being connected to leads 793 and 800 which, in turn, are adapted to be connected to lead 775 when the league play control relay 617 is energized by closure of switch 922.

The energizing coil for relay 620 is connected through lead 761 to the other alternate contacts (FIG. 14B) on the levels 602–A–L5 and 602–B–L5. As will be seen, the relays 619 and 620, corresponding to the block 294 in FIG. 10, serve to connect the amplifiers 931–934 of one alley or the other to the master circuit comprising the scoring, totalizing and results printing units of FIGS. 15A–15F. When bowlers are bowling on a single alley and league play is not employed, the switch 922 (FIG. 14A) will be open whereby lead 713 will be permanently connected to lead 775, meaning that whenever one of the player pushbutton A or B is depressed and the contacts on relays 641A and 641B are closed, power will be supplied to the energizing coil for relay 619 each time a bowler depresses his pushbutton, and this occurs during the entire game while bowling occurs on one alley. If on the other hand, league play is employed whereby the bowlers alternate on two adjacent alleys, the switch 922 (FIG. 14A) will be closed whereby lead 713 will no longer be connected directly to lead 775. Rather, lead 713 will be connected to alternate contacts on levels 602–A–L5 and 602–B–L5 whereby the lead 713 will be connected through either lead 793 or 800 to lead 775 during every other frame (i.e., on odd-numbered frames). On the intermediate or even-numbered frames, the lead 761 will be connected through level 602–A–L5 or 602–B–L5 to the lead 775. The result is that in league play, the relay 619 will be energized for each player in the first frame; in the next frame the relay 620 will be energized; in the next frame the relay 619 will be energized; and so on. Furthermore, energization of relays 619 and 620 is controlled independently by each player pushbutton A or B. That is, since the lead 775 is energized through normally open contacts on the player relays 641A and 641B, the particular relay 619 or 620 which is energized will be dependent upon the number of frames which a particular bowler has bowled previously, and this regardless of the number of frames which the other bowlers have bowled previously.

It will be noted that the contacts 963, 967, 968 and 969 on the pinfall detecting units for the alley of FIG. 15A are each connected through lead 722 to a pair of normally open contacts on a timer motor relay 644. The other side of these normally open contacts are connected to lead 561 which, in turn, is connected through normally closed contacts on a pin-spotter recycle relay 642 to a source of positive voltage. Thus, assuming that relay 642 is deenergized and that relay 644 is energized, power will be supplied to each of the contacts 963, 967, 968 and 969 on the pinfall detecting units.

The other sides of the contacts 963, 967, 968 and 969 are each connected through leads 718, 719, 720 and 721 to sets of normally open contacts on the alley connecting relay 619. In a similar manner, corresponding leads 718–M2, 719–M2, 720–M2 and 721–M2 from the pinfall detecting apparatus on the second alley circuitry, identified as M–2, are connected to sets of normally open contacts on the alley control relay 620. It can be seen that when relay 619 is energized, and its contacts closed, the leads 718, 719, 720 and 721 will be connected through lead 728 to the pull-in coil of a relay 701 and through leads 729, 730 and 731 to the motor magnets of stepping units 702, 703 and 704 (FIG. 15B), respectively. On the other hand, when relay 620 is energized and relay 619 deenergized, lead 718–M2 will be connected to lead 728 while leads 719–M2, 720–M2 and 721–M2 will be connected to the leads 729, 730 and 731 respectively. the arrangement being such that relay 701 and the motor magnets of the units 702, 703 and 704 will be connected to the pinfall detecting apparatus of the first alley when relay 619 is energized, and to the pinfall detecting apparatus of the second alley M–2 when relay 620 is energized.

When relay 619 is energized, it closes normally open contacts to connect lead 717 to a source of positive voltage as shown, thereby energizing an indicating lamp 970 which indicates that relay 619 is energized and that the bowler should be bowling on alley M–1. In a similar manner, when relay 620 is energized it closes a set of normally open contacts to energize indicating lamp 971 to indicate that bowling should occur on the second alley M–2. Naturally, if the league play switch 922 (FIG. 14A) is not closed, the indicating lamp 970 will be energized each time a player relay 641A or 641B is energized.

When relay 619 is energized, it also connects lead 724 to lead 509. Lead 724 is connected to a normally open cam switch 975–2 on a timer motor 975 (FIG. 15B), the other side of the cam switch being connected to lead 561 which, in turn, is connected through the normally closed contacts on relay 642 (FIG. 15A) to a source of positive voltage. Relay 620 is also provided as shown with contacts for connecting leads 509 and 724. The lead 509 is connected to pulse generating relay 621 (FIG. 15B), and this relay is such that as long as lead 509 is energized, the relay 621 will continue to be pulsed or energized intermittently.

Gutter Ball and Foul Detectors

Included in each of the detecting, totalizing and printing circuits for each alley is a gutter ball detector 972 and a foul detector 973. A full and detailed description of the gutter ball detector 972 may be had by reference to copending application Serial No. 149,664, filed November 2, 1961, now Patent No. 3,091,457, and assigned to the assignees of the present application. For purposes of the present description, however, it will be sufficient to state that in the event a ball leaves the alley before knocking down pins, it will close the limit switch 972 to energize lead 550 which is connected through normally open contacts on relay 619 to lead 712. The lead 712, in turn, is connected to the pull-in coil for gutter ball relay 640, which is actuated each time the limit switch 972 is closed. The foul detector switch 973 will be closed whenever a foul occurs. Although shown herein as a simple limit switch, usually the foul detector will take the form of a photoelectric cell in the path of a light beam across the foul line on a bowling alley such that the switch 973 will be closed whenever a bowler steps over this foul line. When the switch 973 is closed, it energizes lead 546 which, in turn, is connected through normally open contacts on relay 619 to lead 446, this lead being connected to the pull-in coil for the foul detector relay 639. Thus, whenever a gutter ball condition occurs,

relay 640 will be energized; whereas whenever a foul occurs relay 639 will be energized. In a similar manner, leads 550 and 546 on relay 620 are connected to the foul and gutter switches, not shown, for alley M–2 such that when relay 620 is energized, a foul or gutter ball occurring on the second alley will energize relay 639 or 640.

Key Release Solenoid—Prevention of Bowler Bowling in Wrong Alley in League Play

Also connected to normally open contacts on relay 619 is a lead 443 which is connected (FIG. 14A) to a key release solenoid 974 which acts to release all of the player pushbuttons when it is energized. Lead 443, in turn, is adapted to be energized through lead 715 which is connected to the circuit for alley M–2, and particularly to a pair of normally open contacts on a relay corresponding to relay 620 in the circuit for alley M–2. Thus, in the case of league play, a bowler from alley M–2 could be bowling on alley M–1, and should a bowler from alley M–1 attempt to connect into alley M–1 at this time while it is being used by a bowler from alley M–2, the solenoid 974, being energized, will automatically reject his pushbutton, thereby disconnecting him from alley M–1 while the bowler from alley M–2 is bowling in alley M–1. In a similar manner, the relay 620 as shown in FIG. 15A for alley M–1 is provided with a pair of normally open contacts having one side connected to a source of positive voltage and the other connected through lead 715–M2 and a pair of normally open contacts on relay 619 in alley M–2, not shown, to lead 433 in alley M–2. Thus, if a bowler from alley M–1 is bowling in alley M–2, and a bowler from alley M–2 attempts to depress his pushbutton, such depression of the pushbutton will be prevented by energization of the key release solenoid 974 for the alley M–2.

Anti-Cycle Relay—Means to Prevent Pin-Spotter from Cycling When No Player Pushbuttons Are Depressed

As was mentioned above, when a bowler prepares to bowl, he should depress his appropriate pushbutton before delivering a ball. It might happen, however, that a bowler forgets to depress his pushbutton before delivering the ball, meaning that his frame and storage units of FIGS. 14A–14D are not connected to the master circuit. If an automatic pin-spotter is used in conjunction with the present invention, and if that pin-spotter is permitted to cycle when no player pushbutton has been depressed, the pinfall results of the ball delivered will, of course, not be recorded. Accordingly, the present invention provides a means whereby the pin-spotter is prevented from cycling when no player pushbutton is depressed, thereby immediately alerting the bowler to the fact that he has failed to depress his pushbutton. This condition can be simply corrected by the bowler depressing his proper pushbutton, whereupon the pinfall results of that ball will be registered, the pin-spotter will cycle, and the scoring of the game will proceed in the normal manner.

The foregoing is accomplished in the following manner: With reference to player relay 619, it will be noted that it is provided with a pair of normally closed contacts which connect lead 553 to lead 535. Lead 535 is connected through normally open contacts on cam switch 975–2 of the timer motor 975 to lead 561, this lead being connected to a source of positive voltage through the normally closed contacts of recycle relay 642. The lead 553, on the other hand, is connected through a pair of normally closed contacts 975′ on relay 620–M2 for alley M–2, these contacts being on the relay in the circuitry for alley M–2 corresponding to relay 620 which serves to cross-connect the alleys. After passing through the normally closed contacts 975′ of the relay 620–M2, the lead 553 is connected to the pull-in coil of relay 646. Thus, if relay 619 is deenergized, and relay 620-M2 is also deenergized, meaning that none of the player pushbuttons are depressed and neither of the standing pin detectors are connected to the master circuit, the relay 646 will pull in to energize relay 643, thereby breaking the circuit to the pin-spotter control relay, generally indicated at 975P in FIG. 15A. Thus, under the circumstances described, the pin-spotter will not cycle, thereby alerting the bowler that he has failed to depress his pushbutton. This condition may be corrected by thereafter depressing the proper pushbutton, whereupon relay 619 for alley M–1 or relay 620 for alley M–2 will become energized to break the circuit to the pull-in coil for relay 646 and energize the circuit to the release coil for this same relay through lead 539. In this respect, it will be noted that the lead 539 is not only connected to lead 775 in alley M–1, but is also adapted to be connected to the corresponding lead 775–M2 on relay 620 in alley M–2. Thus, when a player pushbutton in either alley is depressed, the relay 646 will be reset to permit the pin-spotter to cycle. It will be noted that the relay 620 for alley M–1 is provided with a pair of normally closed contacts 975′ as is the relay 620–M2 for alley M–2.

If, for some reason, it is desired to cycle the pin-spotter without depressing a player pushbutton, the pushbutton 976 of FIG. 15A may be depressed for this purpose. Similarly, if it is desired at any time to prevent pinfall from being registered after a ball is delivered, this may be accomplished by depressing the pushbutton 977 to energize the pull-in coil for recycle relay 642, thereby deenergizing lead 561 and lead 722 which is connected to lead 561 through the contacts of relay 644.

Thus, whenever relay 619 or 620 is energized, the following things happen: First, the pinfall detecting circuits are connected to relay 701 as well as the motor magnets for units 702, 703 and 704; indicating light 970 or 971 is energized, the gutter and foul detectors 972 and 973 are connected into the circuit; the pulse generator 621 is connected into the circuit; the deenergizing coil for anticycle relay 646 is connected to any one of the player relays; and the pull-in coil for the anti-cycle relay 646 is disconnected from a power source through lead 553.

Timer Motor

As will be seen, it is the function of timer motor 975 (FIG. 15B) to control a sequence of operations each time a ball is delivered, and particularly the operation of the standing pin detectors. Let us assume, for example, that the relay 619 is energized. Under these circumstances, the pinfall detecting circuits for alley M–1 will be connected to relay 701 as well as the motor magnets for units 702, 703 and 704. When a bowler prepares to bowl, he will depress his appropriate pushbutton, thereby energizing his appropriate player relay 641A, 641B, and so on. Thereafter, he will deliver his ball, and when the ball strikes the backstop 34 (FIG. 1), it will close limit switch 978 (FIG. 15A), thereby energizing relay 644 to close its normally open contacts. When the contacts of relay 644 close, lead 722 which is connected to contacts 963, 967, 968 and 969 is energized through lead 561. At the same time, when relay 644 is energized, its closed contacts momentarily energize the timer motor 975 (FIG. 15B) through closed contacts on relay 646 and leads 361 and 770. As soon as the timer motor is energized by relay 644 and starts to rotate, the switch on cam 975–4 will close to permanently connect leads 361 and 770 to cause it to rotate through a complete revolution and then stop. When the timer motor 975 rotates through 135°, the cam switch on cam 975–1 will close, thereby connecting lead 723 to lead 561. Consequently, lead 723 will be energized at 135° of rotation of the timer motor, and when this occurs a motor control circuit 979 (FIG. 15A) is actuated to energized motor 930 which causes the coils 926, 927, 928 and 929 to sweep across the tops of the pins.

Standing Pin Registers

Assuming that the No. 1 pin has not been knocked down in Zone I (FIG. 10), a pulse will be induced in coil 926 which, in turn, will cause a pulse on leads 718 and 728 to

energize the pull-in coil on relay 701, thereby closing its normally open contacts to connect lead 547 to lead 570. The lead 547, in turn, is connected through normally closed contacts of gutter ball relay 640, lead 836, and the normally closed contacts of foul relay 639 to a source of positive voltage. Thus, as long as neither a gutter ball nor foul occur, lead 547 will be energized to supply energy to one side of the contacts on relay 701 as well as the cam switches on units 702, 703 and 704. Let us assume further that the No. 2 pin is left standing while the No. 3 pin has been knocked down in Zone II. Consequently, only one pulse will be induced in the coil 927 to produce a single pulse on leads 719 and 729 which, in turn, pulses the motor magnet for unit 702 once which will close the cam switch on cam 702–2. If two pins were left standing in Zone II, the switches on both cams 702–2 and 702–1 would be closed since the motor magnet for unit 702 would have been pulsed twice. The switch on the cam 702–1 is connected to lead 571 whereas the switch on cam 702–2 is connected to lead 572.

In a somewhat similar manner, the coil 928 is connected through leads 720 and 730 to the motor magnet for unit 703 to pulse that unit a number of times corresponding to the number of standing pins in Zone III covered by coil 928. Let us assume, for example, that three pins are left standing in the third row or Zone III. Under these circumstances, the cam switches on each one of the cams 703–1, 703–2 and 703–3 would be closed to energize each one of the leads 573, 574 and 575. Finally, the motor magnet for unit 704 (FIG. 15B) will be pulsed a number of times corresponding to the number of standing pins in the last row or Zone IV so that, if it is assumed that three pins are standing in the last row the motor magnet for unit 704 will be pulsed three times, thereby closing the cam switches on cams 704–2, 704–3 and 704–4. If four pins are left standing in the last row, then the motor magnet for unit 704 will be pulsed four times and the cam switch on cam 704–1 will also be closed. Closure of the cam switches on cams 704–1, 704–2, 704–3 and 704–4 will, in turn, energize leads 576, 577, 578 and 580.

The leads 570–580 are, in turn, connected to contacts on the fourth contact level 608–L4 of a stepping switch 608 (FIG. 15B). The stepping switch 608 is energized through lead 402 which, in turn, is connected through a normally open contact on pulse generating relay 621 to a source of positive voltage. Thus, each time the pulse generating relay 621 is energized, its normally open contacts will close to, in turn, pulse the stepping unit to advance all of its wiper brushes on levels 608–L1, 608–L2, 608–L3 and 608–L4 once. The initial pulse for the pulse generating relay 621 is received on lead 509 through contacts on relay 619 or 620, one of which is now energized, and the lead 724 which, in turn, is connected to lead 561 and a source of positive voltage through the switch on cam 975–2 when the timer motor has rotated through 250°. By this time, however, all of the coils 926–929 will have been swept across the tops of the pins since the motor 930 was energized at 135° of rotation of the timer motor. Once the pulse generating relay 621 is initially pulsed through lead 509, it will continue to pulse by virtue of the capacitor 980 connected in parallel with its energizing coil. That is, when the relay 621 is initially pulsed, the stepping unit 608 will also be pulsed, thereby closing its cam switch on cam 608–C. This, in turn, connects a source of positive voltage to the lead 509 each time the normally closed contacts on pulse generating relay 621 are closed. Thus, on the first pulse the relay 621 will be energized and then deenergized, and when it is deenergized its normally closed contacts will be connected to a source of positive voltage to again energize it, whereupon it will become energized and deenergized alternately until the cam 608–C makes a complete revolution to open the cam switch thereon.

Conversion of Standing Pin Count to Fallen Pin Count—First Ball

As the stepping unit 608 passes through the first 180° of travel of the wiper brushes thereon, the wiper brush on level 608–L4 will make contact with leads 570–580 in succession. Thus, a number of pulses will appear on the wiper brush on level 608–L4 and the lead 518 connected thereto with the number of pulses corresponding to the number of standing pins detected by the coils 926–929 (FIG. 15A). These pulses are then applied through contacts on the pulse generating delay 621 to lead 521. The lead 521 is adapted to be connected through normally closed contacts on the second ball latch relay 635 (FIG. 15F) to lead 492 which, in turn, is connected to the motor magnet for stepping unit 606 (FIG. 15B). As will hereinafter be seen, when the first ball of each frame is delivered, the contacts of relay 635 will be in the positions shown; whereas on the second ball the positions of the contacts will be reversed. Consequently, on the second ball it will be seen that the lead 521 from the pulse generating relay 621 will be connected to lead 493 rather than lead 492, and lead 493 is connected to the motor magnet on the second ball stepping unit 607 (FIG. 15B). The lead 521 is also adapted to be connected to lead 513 through normally open contacts on foul and gutter ball relays 639 and 640, respectively (FIG. 15A). That is, whenever relay 639 or 640 is energized, the lead 521 will be connected to lead 513 which, in turn, is connected to the single contact point on level 608–L1 of stepping unit 608.

Assuming that the first ball is being rolled and that the relay 635 is not pulled in so that its contacts are in the positions shown, the lead 521 will be connected to lead 492 whereby the stepping unit 606 will be pulsed. Stepping unit 606 has six levels thereon identified as 606–L1, 606–L2, 606–L3, 606–L4, 606–L5 and 606–L6. Let us assume, for example, that six pins are left standing after the first ball, meaning that as the wiper brush on level 608–L4 scans across the contacts connected to leads 570–580, six pulses will be induced in lead 518 to pulse the motor magnet for stepping unit 606 six times. Under the circumstances, each of the wiper brushes on levels 606–L1 to 606–L6 will be on the No. 6 contact, identified as 981. The contact 981, it will be noted, is connected to leads 587, 586, 585 and 584, meaning that four contact points on the level 608–L3 will be energized, assuming that lead 499 which is connected to all of the wiper brushes on levels 606–L2 to 606–L6 is energized. The lead 499 is connected to lead 547 through normally closed contacts on the second ball relay 635 (FIG. 15F), meaning that the brushes on levels 606–L2 to 606–L6 will be energized on a first ball cycle, and only a first ball cycle if lead 547 is energized through relays 639 and 640 (FIG. 15A).

Let us assume, now, that only three pins remain standing after a ball has been rolled, with the result that the wiper brushes on stepper unit 606 are advanced three positions. Under these circumstances, the wiper brush on level 606–L2 is connected through lead 583 and normally closed contacts on second ball latch relay 635 (FIG. 15F) to lead 852 which, in turn, energizes relay 637 (FIG. 15B). The relay 637, when energized, will close its normally open contacts to energize leads 587, 586, 585, 584 and 588 from lead 547 (relays 639 and 640 in FIG. 15A) which is connected to the other side of the normally open contacts on relay 637. Thus, assuming that five or less pins remain standing after a ball is delivered and no foul or gutter ball occurs, the relay 637 will always be energized to energize at least five of the leads connected to the contact points on level 608–L3. The remaining energized contact points are then derived from the levels 606–L6 to 606–L3. Thus, assuming that the wiper brushes are on contact point 982 and that three pins remain standing, the wiper brush on level 606–L4 will energize lead 590 and the wiper brush on level 606–L3 will ener-

gize lead 589, for a total of five leads energized by the relay 637 plus two leads energized by levels 606–L4 and 606–L3, indicating that seven pins have been knocked down. From a consideration of the operation of the unit 606 and its associated relay 637 it will be seen that it converts pulses corresponding to the number of standing pins on level 603–L4 into energized leads on level 603–L3 corresponding to the number of pins knocked down by the first ball.

All of the foregoing occurs in the first 180° of travel of the stepping unit 608. During the second 180° of travel of the stepping unit 608, the wiper brush on level 608–L3 will sweep across its contact points, thereby becoming energized a number of times corresponding to the number of pins knocked down. These pulses, in turn, are applied through lead 517 and contacts on pulse generating relay 621 to lead 516. Lead 516, in turn, is connected through normally closed contacts on the second ball latch relay 635 (FIG. 15F) to lead 493 which is connected to the motor magnet for second ball stepping unit 607. Thus, the second ball stepping unit 607 is advanced seven times preparatory to the rolling of the second ball. As will be seen, this is done in order to subtract the fallen pins due to the first ball from ten in determining the number which are knocked down by the second ball.

The lead 516 is also connected to the motor magnet for stepping units 603 (FIG. 15C) having five levels 603–L1, 603–L2, 603–L3, 603–L4 and 603–L5 thereon. Thus, the wiper brushes on the various levels of unit 603 are also advanced over seven contact points. The levels on stepping unit 603 are somewhat similar to the levels on unit 606, and include a relay 625 adapted to be energized when the wiper brush on level 603–L1 is on the 5th to 9th contact points. Thus, whenever at least five pins have been knocked down, the relay 625 will be energized to thereby energize four contact points on level 601–L5 of stepping unit 601 (FIG. 15C) through leads 732, 733, 734 and 735. In addition, whenever the wiper brush on level 603–L1 is on the 5th to 9th contact point, the lead 750 which energizes the relay 625 will also energize the 5th contact point on the level 601–L4. In the case assumed above where seven pins have been knocked down, the wiper brushes on the stepping unit 603 will be on contacts 983. Under these circumstances, leads 736 and 737 will be energized to energize an additional two contacts on level 601–L4 to indicate that seven pins have been knocked down; however, the leads 738 and 739 on levels 603–L5 and 603–L6 will not be energized. On the other hand, if less than five pins have been knocked down by the first ball, the relay 625 will not be energized, but leads 732, 733 and 734 will be energized to energize three contact points on level 601–L4 to indicate that three pins have been knocked down.

From a consideration of the stepping unit 603, it will be seen that a number of leads connected to the level 601–L4 will be energized corresponding to the number of pins knocked down. The brushes on the various levels of stepping unit 603 and the contacts on relay 625 are conected via lead 448 to normally closed contacts on spare control relay 633 (FIG. 15F) and thence to lead 445 which, in turn, is connected through normally closed contacts on strike control relay 632 to lead 442 which is connected through normally closed contacts of tenth frame zero cycle control relay 628 (FIG. 15A) to a source of positive voltage.

When the initial pulse is received on lead 509 for pulse generating relay 621 (FIG. 15B), contacts on relay 621 connect the lead 408 to a source of positive voltage. This lead is connected through the normally closed contacts on the cam switch for cam 608C to lead 512 which, in turn, is connected to the pull-in coil for first ball latch relay 634 (FIG. 15F), thereby closing its normally open contacts, which contacts serve a purpose in the tenth frame, hereinafter described.

Results Printing—First Ball With No Strike

After unit 608 (FIG. 15B) rotates through a complete 360° cycle, the cam switch on cam 608C will open to break the circuit to pulsing relay 621 to stop further rotation of the wiper brushes on unit 608. However, at this point the wiper brush on level 608–L1 makes contact with lead 513 which, in turn, energizes the pull-in coil for results print relay 629 (FIG. 15E). When relay 629 is energized, the positions of its contacts are reversed from those shown in the drawings with the result that lead 410 is connected to a source of positive voltage. The lead 410, in turn, energizes the printer drive motor 118 (also shown in FIGS. 3 and 10) to rotate the six cams 288–1, 288–2, 288–3, 288–4, 288–5 and 288–6. Each of cams 288–1, 288–2, 288–3, 288–4 and 288–6 has a cam switch thereon which is connected to a source of positive voltage; whereas cam 288–5 is connected to ground. When the printer drive motor 118 begins to rotate, the switch on cam 288–1 immediately closes to connect the printer drive motor to a source of positive voltage for 360° of revolution. At 5° of rotation of the printer drive motor 118, the cam switch on cam 288–6 will close to energize lead 468, which lead is connected through cables P and M to the release solenoids 188 on each of the score printing wheels 130, 132 and 134 (FIG. 14D) and each of the results printing wheels 136, 138 and 140 (FIG. 15C), respectively. That is, lead 468 is connected to each of the release solenoids 188H, 188T and 188U of FIG. 14D as well as the release solenoids 188F, 188S and 188B for the first, second and bonus ball results printing wheels. The other sides of each of the solenoids 188 are connected through lead 463 and the switch on cam 288–5 to ground. As can be seen, this switch remains closed for 190° of rotation of the printer drive motor 118 and serves also to ground one side of each of the index coils 186H, 186T and 186U shown in FIG. 14D.

By the time stepping unit 608 (FIG. 15B) has rotated through 360°, the unit 606 is pulsed a number of times corresponding to the number of standing pins. If it is assumed that six pins have been knocked down, the wiper brush on level 606–L1 would have been advanced to the fourth contact, and this contact is connected to the No. 6 contact on each of the insulating boards 196F, 196S and 196B for the ball results printing wheels. The wiper brush on level 606–L1 is energized at this time through lead 474 connected through normally closed contacts on second ball latch relay 635 (FIG. 15F) to lead 443. Lead 443 is connected through normally closed contacts on score print relay 631 (FIG. 15E) to lead 735. Lead 735, in turn, is connected through normally closed contacts on spare control relay 633 (FIG. 15F) to lead 445; and lead 445 is connected through normally closed contacts on strike control relay 632 to lead 442 which is connected through normally closed contacts on tenth frame zero cycle control relay 628 (FIG. 15A) to a source of positive potential. Thus, before the one-to-nine pinfall results of the first ball (i.e., other than a strike or spare) can be printed, the contacts of relay 635 must be in the positions shown, as well as those of relays 631, 632 and 633. Since the printer drive motor 118 is rotating, and since all of the brushes on the insulating boards are connected to this score printer drive motor, they will rotate also. Since, however, we are now in a first ball cycle, only the index solenoid for the insulating board 196F for first ball results printing can be energized.

This is accomplished through lead 743 which is connected to the index solenoid 186F; and the index solenoid, in turn, is connected through lead 471 and a closed cam switch on cam 609–2 of a tenth frame ball counting stepping unit 609 to lead 469. Lead 469, in turn, is connected through normally closed contacts on second ball latch relay 635 (FIG. 15F) to lead 463, this lead being connected to ground during this time by the cam switch

on cam **288–5** (FIG. 15E). The gear ratio between the cams on the score printer drive motor **118** and the wiper brushes on the insulating boards **196F**, **196S** and **196B** is such that the wiper brushes will have completed a full revolution before the cams **288–1** to **288–6** rotate through 190° such that the ground connection for the index solenoid **186F** will not be broken until the first ball results are printed. At 190°, then, the circuit to the index solenoid **186F** will be broken whereby the wiper brush on insulating board **196F** may be returned to its zero starting position where it engages the lever arm **190** (FIG. 4) on the release solenoid **188F**. At 355° of rotation of the score printer drive motor cams, the cam **288–2** will connect lead **466** to a source of positive voltage, thereby energizing the pull-out coil for results print control relay **629** (FIG. 15E) and breaking the connection in this relay between lead **410** and the positive source of voltage so that the score printer drive motor will stop after one complete revolution when the cam switch on cam **288–1** opens.

Reset of Standing Pin Registers—First Ball

At the time stepping unit **608** (FIG. 15B) completes one complete revolution and the results print relay **629** is pulled in or energized, the number of fallen pins will already have been registered on the unit **606**. While the printing operation is occurring and the results print relay **629** is energized, the lead **725** (FIG. 15E) is connected to a source of positive voltage, and this lead **725** is used to reset the standing pin registers **701**, **702**, **703** and **704** (FIGS. 15A and 15B). This is accomplished as follows: When lead **725** is energized it energizes the reset coil for relay **701**, thereby opening its contacts. At the same time, the lead **725** is connected through contacts on cam switch **702–3** and through interrupter switch **702–S** to the motor magnet for unit **702**, the result being that each time the motor magnet is energized, the switch **702–S** will open to deenergize the circuit and again close to energize the circuit, thereby pulsing the unit until it rotates through 360° where the cam switch **702–3** is such that its bottom contacts are open and its top contacts are closed. When this occurs, the lead **725** will be connected through the contacts on cam switch **703–4** to the motor magnet for unit **703** through its interrupter switch **703S** until it rotates through 360°, whereupon the lead **725** will be connected through cam switch **704–5** and interrupter switch **704–S** to the motor magnet for unit **704** to step it through 360° until it stops. At this point, all of the standing pin registers **701–704** have been returned to their normal starting positions.

Conversion of Standing Pin Count to Fallen Pin Count—Second Ball

Now, when the second ball in a frame is rolled, the same process described above will be repeated whereby a number of the leads **570–580** will be energized corresponding to the number of standing pins. When the timer motor **975** (FIG. 15B) is energized following the rolling of the second ball and the lead **509** is initially pulsed to pulse the pulsing relay **621**, lead **512** will also be pulsed through normally closed contacts on cam switch **608C**, and this lead **512** will be connected to a cam switch on cam **984–15** (FIG. 15E) connected to a score motor **984** (FIG. 15D) which will now be off normal in a manner hereinafter described so that the switch is closed. Thus, lead **512** will be connected through this switch to lead **429** which, in turn, is connected to the pull-in coil for second ball latch relay **635** (FIG. 15F). Now, lead **521** on relay **635** will be connected to lead **493** rather than lead **492**; and since lead **493** is connected to the second ball stepping unit **607** (FIG. 15B), this unit will be advanced by a number of pulses corresponding to the number of standing pins after the second ball. The various contact levels on unit **607** are the same as those on unit **606**; and, accordingly, a number of contacts on unit **608–L2** will be energized corresponding to the number of fallen pins for the second ball since this level **608–L2** is connected to levels **607–L2** to **607–L7** of unit **607**. Therefore, as the unit **608** rotates through the second half of its revolution after delivery of the second ball, a number of pulses will appear on lead **517** corresponding to the number of pins knocked down by the second ball. These pulses are applied through lead **516** to the motor magnet for stepping unit **603** (FIG. 15C) and effectively added to those pins knocked down by the first ball.

It will be remembered that on the first ball cycle, the lead **517** was connected to lead **516** which, in turn, was connected through contacts on second ball latch relay **635** (FIG. 15F) to lead **493** to advance the unit **607** with the unit **603**. Thus, assuming that six pins were knocked down by the first ball, the unit **607** would have been advanced six times whereby its wiper brushes would be on the No. 6 contacts. On the second ball, however, when second ball latch relay **635** is pulled in, the lead **493** is connected to lead **521** which pulses the unit **607** a number of times corresponding to the number of standing, rather than fallen, pins after the second ball. Accordingly, the number of standing pins after the second ball is effectively subtracted from the number of fallen pins on the first ball to derive the number of pins knocked down by the second ball. For example, if six pins were knocked down with the first ball, the unit **607** would have been advanced six times. Now, if three additional pins are knocked down with the second ball, there will be one pin left standing on the alley, meaning that the unit **607** will be advanced one more contact, with the result that it will now be resting on the seventh contact and energizing the No. 3 contact on level **608–L2** of unit **608**. On the second half of the cycle of unit **608**, therefore, three pulses will be delivered on lead **517** which is connected through lead **516** to the motor magnet for unit **603** to advance it three more steps. Hence, the wiper brushes of unit **603** are now on the ninth contact for a total of nine pins knocked down by both balls in the frame.

Results Printing and Reset of Standing Pin Registers—Second Ball

At the completion of the second ball cycle when the brush on level **608–L1** energizes lead **513**, the results print relay **629** (FIG. 15E) is again energized to energize the printer drive motor **118** which, through its cam **288–6** energizes lead **468** to energize the release coils **188H**, **188T**, **188U** in FIG. 14D and **188F**, **188S** and **188B** in FIG. 15C. In order to print the results of the second ball the wiper brush on level **607–L1** must be energized. This is accomplished through lead **475** connected through normally open contacts on second ball latch relay **635** (FIG. 15F), which are now closed, to lead **443**, the lead **443** being connected through normally closed contacts on score print relay **631** (FIG. 15E) to lead **735**. Lead **735**, in turn, is connected through normally closed contacts on spare control relay **633** (FIG. 15F) to lead **445**; and lead **445** is connected through normally closed contacts on strike control relay **632** to lead **442** which is connected through normally closed contacts on tenth frame zero cycle control relay **628** (FIG. 15A) to a source of positive potential. Thus, before the one-to-nine pinfall results of a second ball can be printed, the contacts of the relays **631**, **632** and **633** must be in the positions shown; whereas the contacts of relay **635** must be reversed with respect to that shown. Assuming that this is the case, lead **475** will be energized to energize the wiper brush on level **607–L1** whereby, in the case of three pins knocked down with the second ball, the No. 3 contact on insulating boards **196F**, **196S** and **196B** will be energized. When the wiper brush on insulating board **196S** reaches the No. 3 contact, the index solenoid **186S** will be energized through lead **714** and lead **472** which is connected through contacts on cam switch **609–2** of unit **609** to lead **470**. Lead **470**, in turn, is connected through

normally open contacts of relay 635 (FIG. 15F), which are now closed, to lead 463, this lead being connected to ground through the switch on cam 288–5 of printer drive motor 118.

Results Printing—Strike or Spare

If a strike is made by knocking down ten pins with the first ball, the units 606 and 607 will not advance since there are no standing pins. Consequently, the lead 530 will now be connected through contacts on cam 606–C (FIG. 15B) to lead 490 which is connected through relay 652 (FIG. 15F) to lead 557. The lead 557, in turn, is connected through normally open contacts on relay 629 (FIG. 15E) to lead 547 which is connected to a source of positive voltage through relays 639 and 640 (FIG. 15A). On the first ball, lead 530 is connected through normally closed contacts on second ball latch relay 635 (FIG. 15F) to lead 498 which, in turn, energizes the pull-in coil for strike control relay 632. When the strike control relay is energized, it connects lead 532 to lead 833. Lead 532 is connected to the strike (marked "X") contact on insulating boards 196F, 196S and 196B and, when energized, will cause the appropriate ball results wheel to print an (X) on the score sheet. The lead 532 is energized upon the occurrence of a strike through the lead 833 on relay 632 (FIG. 15F) which is connected through contacts on results print relay 629 (FIG. 15E), which is pulled in during results printing, to lead 547. The lead 547, in turn, is connected through normally closed contacts on gutter ball and foul relays 640 and 639, respectively, to a source of positive voltage.

The situation for results printing a spare is very similar to that of a strike except that the lead 530 from level 603–L6 of unit 603 (FIG. 15C) will be connected to lead 497 rather than lead 498 since a spare will occur only on a second ball cycle when second ball latch relay 635 (FIG. 15F) is pulled in. Consequently, the spare control relay 633, rather than strike control relay 632, will now be energized to connect lead 833 to lead 531. Lead 833 is energized in the same manner as in the case of a strike, however lead 531 is connected to the spare (marked "/") contacts on insulating boards 196S and 196B so that the printing wheel 138 or 140 will print a (/) on the score sheet.

Results Printing—Foul or Blow

If a foul occurs, relay 639 (FIG. 15A) will be energized to energize lead 522, and this lead is connected to the foul contacts (marked "F") on the insulating boards 196F, 196S and 196B. At the same time, leads 521 and 513 will be connected together to pull in the results print relay 629 (FIG. 15E) to initiate a printing cycle and print an (F) on the score sheet in the proper results box.

Similarly, if a gutter ball occurs and is detected by closure of switch 972 (FIG. 15A), the relay 640 will be pulled in to energize lead 525 connected to the blow contacts (marked "—") on the insulating boards 196F, 196S and 196B. Leads 521 and 513 are again interconnected so that a results print cycle is initiated.

At the completion of the results printing cycle, the lead 466 for the reset coils on foul and gutter ball relays 640 and 649 is energized by the switch on cam 288–2 of the printer drive motor 118 (FIG. 15E), thereby resetting either one or both of these relays.

Score Motor and Mark Relays

As will be understood, the operation of the circuit described to this point occurs during each frame, except the tenth, with the ball results being printed in the results boxes 46 shown in FIG. 2. A score printing cycle, however, does not occur during every frame. That is, whenever a mark is made in a frame, scoring is delayed until the next or successive frame.

It is the purpose of the score motor 984 (FIG. 15D) and its associated mark relays 618, 615, 616 and 614 to control the printing operation such that in the case of normal frame play where no marks are made the score is printed immediately; whereas in the case of a mark, scoring is delayed until the next or successive frames are played. The maximum number of frames played without scoring is two, in which case a double or two successive strikes would have been made in the preceding frames.

Referring now to the score motor 984, it will be noted that it is connected to sixteen cams identified as 984–1 to 984–16. At the time the score print results relay 629 is energized, the score motor 984 will be rotated through a predetermined number of degrees. After the first ball is rolled with no previous marks and with no strike made in the frame being played, the score motor will rotate through 180° and stop. If a strike is made with the first ball and with no previous marks the score motor will rotate through a complete 360° revolution and stop. Similarly, with a strike made in the previous frame and a strike made in the frame being played, the score motor will again rotate through 360° and stop. If a double has been made previous to the frame being played and if a strike is made in the frame being played, the score motor will rotate through 90° and stop. Similarly, if a spare is made in the previous frame, the score motor will rotate through 90° with the rolling of the first ball, stop and score, and then go to 180° and stop. If a spare is made in the frame being played on the second ball, the score motor will rotate through 360° and stop. In normal frame play with no previous marks made and when no marks are made with the second ball in the frame being played, the score motor will rotate through 270° and stop, print the score, and then rotate through an additional 90° to complete one revolution.

Each of the relays 614–618 is controlled from the player storage circuits, and particularly the strike-spare holding units 610A and 610B (FIG. 14A) for the two players shown. Considering zero mark relay 614, it will be energized whenever there are no previous marks credited to a particular bowler when that bowler's particular pushbutton is depressed. Thus, the relay 614 is energized through lead 458 which is connected through cable P to a set of normally closed contacts on cam switches 610–B–3 and 610–A–3. With no marks previously made for a particular player, the cams will be in the positions shown in FIG. 14A whereby the lead 458 will be connected, for example, through normally closed contacts on cam switches 610–A–2 and 610–A–1 to lead 637. The lead 637, in turn, is adapted to be connected to lead 457 through normally open contacts on player relay 641A. In a similar manner, lead 458 is connected through normally closed contacts on cam switches 610–B–3, 610–B–2 and 610–B–1 to lead 638, this lead being adapted to be connected to lead 457 through normally open contacts on the plyaer relay 641B. Thus, the mark zero relay 614 will be energized with no previous marks when lead 457 is energized and either one of the player relays 641A or 641B is energized. The lead 457, in turn, is connected through normally closed contacts on the results print control relay 629 (FIG. 15E) to lead 442 which, in turn, is connected through normally closed contacts on the tenth frame zero cycle control relay 628 (FIG. 15A) to a positive source of voltage. Thus, the zero mark relay 614 will be energized whenever no previous marks have been made and a player pushbutton is depressed, when the results print control relay 629 is deenergized with its contacts in the positions shown, and when the tenth frame zero cycle control relay 628 is deenergized with its contacts in the positions shown. The tenth frame zero cycle control relay 628, however, will be energized in the tenth frame under special conditions which will hereinafter be described.

With reference now to the mark spare relay 615, it is energized through lead 459 connected through cable P to a normally open switch on cams 610–A–3 and 610–B–3. When a spare is made and the unit 610A or 610B is

advanced one step in a manner hereinafter described, the switch to which lead 459 is connected will close, thereby connecting lead 459 to lead 637 or lead 638 through normally closed contacts on the switches on cams 610–A–2 and 610–A–1 or 610–B–2 and 610–B–1, depending upon which player pushbutton is depressed. The leads 637 and 638, in turn, will be connected to the energized lead 457 when any player pushbutton is depressed. It can thus be seen that the mark spare relay 615 is energized in much the same way as the mark zero relay 614, except that this latter relay 615 will be energized rather than relay 614 when unit 610A or 610B is pulsed once in response to a spare having been made.

Energization of the mark strike relay 616 is similar to that of relays 615 and 614. That is, it is energized by lead 460 which is connected through cable P to the normally open top contacts on cam 610–A–2 or 610–B–2. These contacts will be closed when unit 610A or 610B is pulsed twice in response to the occurrence of a strike, thereby connecting the lead 460 to lead 637 or 638 and thence to lead 457 to energize the mark strike relay 616.

The mark doubles relay 618, on the other hand, is energized by lead 461 connected through cable P to the normally open bottom contacts on cam 610–B–1 or 610–A–1. The cam 610–B–1 or 610–A–1 is such that it will close the contacts between lead 461 and lead 637 or 638 in response to four pulses applied to unit 610A or 610B. It will be remembered that in the case of a strike, two pulses were applied to the unit 610A or 610B. In the case of a double, therefore, two pulses would have already been applied to the unit 610A or 610B, and when the next successive strike is made, two additional pulses are applied to step the unit a total of four times and close the contacts between leads 637 or 638 and 461, thereby energizing the mark doubles relay 618 through lead 457 which is now energized. As will be seen, the units 610A and 610B are advanced by the score motor 984 and its associated cams 984–8 and 984–9.

With reference now to the score motor 984 (FIG. 15D), it is initially energized through lead 441 which is connected through cable M to normally open contacts on score motor control relay 630 (FIG. 15A), the other side of these normally open contacts being connected to a source of positive voltage. Relay 630 is energized through lead 454 which, in turn, is connected through normally open contacts on results prints control relay 629 (FIG. 15E) to lead 406 connected to a cam switch on cam 288–3 on the printer drive motor 118 such that it will be closed at 350° of travel of the printer drive motor. The score motor control relay 630 is also adapted to be energized, however, through lead 545, normally closed contacts of the mark strike relay 616, lead 418, the normally open contacts of score print control relay 631 and lead 406. Thus, relay 630 will be energized to initiate the score motor 984 after the printer drive motor has been energized and has rotated through 350° and if the results print control relay 629 is energized or if the score print control relay 631 is energized while the mark strike relay 616 is deenergized. This means, in effect, that the score motor 984 will be initially energized each time a ball results printing cycle ends (i.e., at 350° of travel of cam 288–3), but not every time that a score print cycle occurs. That is, it will occur on a score print cycle only when the mark strike relay 616 is deenergized and leads 454 and 418 connected, meaning that no strike has been made in the frame being played or held as a result of previous strike or strikes made.

After the score motor 984 is initially energized, it will rotate for at least 90° since the lead 441 will now be connected to a source of positive voltage through the cam switch on cam 984–14. That is, at 90° of travel, the cam switch 984–14 will open, meaning that the score motor 984 will continue to rotate only if the score motor control relay 630 is energized.

With reference now to cams 984–4, 984–5 and 984–6, it will be noted that each is provided with a normally open cam switch connected on one side to lead 409, this lead 409 being connected to the pull-out or release coil for relay 630; and since the score motor 984 is initially energized when relay 630 is energized, energization of the lead 409 will act to deenergize the score motor. The lead 409 is connected to lead 413 when the cam switch on cam 984–4 closes and thence through normally open contacts on mark doubles relay 618 or mark spare relay 615 to lead 442 which, in turn, is connected through normally closed contacts on the tenth frame zero cycle control relay 628 (FIG. 14A) to a source of positive voltage. The lead 413 is also adapted to be connected through normally open contacts on the mark strike relay 616 to lead 445 which, in turn, is connected through normally closed contacts on strike control relay 631 (FIG. 15F) to the same lead 442 which is connected to a source of positive voltage through normally closed contacts on the tenth frame zero cycle control relay 628. The notch in cam 984–4 is spaced at 85° from the point of initial rotation of the score motor 984. Thus, at this point, the score motor control relay 630 will pull out whereby, when cam 984–14 reaches 90° the notch provided at this point is adapted to break the circuit to the score motor 984 to stop it.

The lead 409 is also adapted to be connected through normally open contacts on cam 984–5 to the lead 445 which, in turn, is connected through normally closed contacts on strike control relay 632 to lead 442 which is energiezd through the normally closed contacts on the tenth frame zero cycle control relay 628. Therefore, the lead 409 will be energized to stop the score motor at 180° of travel whenever a strike has not been made and the strike control relay 632 is deenergized.

The lead 409 is also connected through normally open contacts on cam 984–6 to lead 430 connected through normally open contacts on mark zero relay 614 to lead 448, this lead being connected through normally closed contacts on spare control relay 633 to lead 445 which passes through normally closed contacts on the strike control relay 632 to lead 442, this lead being the one which is connected to a source of positive voltage through normally closed contacts on the tenth frame zero cycle control relay 628 (FIG. 15A). Thus, the score motor 984 will stop at 270° if zero mark relay 614 is energized indicating that no marks have been made, and both the spare control and strike control relays 633 and 632, respectively, are deenergized. When the score motor 984 rotates past 270°, it will be deenergized at 360° by the lower normally open cam switch on cam 984–7 which connects the lead 409 to a source of positive voltage, thereby deenergizing the score motor control relay 630.

Thus, the score motor 984 will rotate through 90°, 180°, 270° or 360° and stop, depending upon the condition of the mark relays 614–618, relays 632 and 633, and the zero cycle control relay 628. However, in any event, it will always stop after 360° by virtue of the cam switch on cam 984–7.

The notches in the cams 984–1, 984–2 and 984–3 are located at the same angular positions as the notches in cams 984–4, 984–5 and 984–6, respectively. These cam switches on each of the cams 984–1, 984–2 and 984–3 are connected to lead 545 which, in turn, is connected to the energizing coil for the pulse generating relay 651, this relay being similar in operation to the pulse generating relay 621 already described. Once the pulse generating relay 651 is pulsed (i.e., receives an initial pulse through lead 545), it will close a pair of normally open contacts to connect lead 442 to the energizing coil for stepping unit 601, thereby closing the cam switch on cam 601–C. When the switch on cam 601–C closes, a source of power is supplied to the pulse generating relay 651 from lead 442 and lead 555, as well as the normally closed contacts on the pulse generating relay 651. Thus, the pulse generating relay 651 will continue to pulse until

the wiper brushes on unit 601 have made a complete revolution.

It iwll be remembered that a number of leads connected to the contact points on level 601–L4 will be energized corresponding to the number of fallen pins. Thus, as the wiper brush on level 601–L4 sweeps across the energized contact points, a number of pulses will be induced in lead 421 corresponding to the number of fallen pins. These pulses are applied through contacts on pulsing relay 651 to lead 449 which, in turn, is connected through cable P to contacts on the player relays 641A and 641B (FIG. 14A). Considering player relay 641A, for example, the lead 449 is adapted to be connected to lead 625 which will pulse stepping unit 604A a number of times corresponding to the number of fallen pins. In this manner, it can be seen that the pinfall will be registered on units 604A and 605A as the game progresses. Similarly, if the player pushbutton B is depressed, that player's pinfall will be added to his previous pinfall in the units 604B and 605B. The other side of the motor magnet for unit 604A or 604B is adapted to be connected through lead 823 to the wiper brush on level 601–L3, this wiper brush contacting lead 764 during the first nine steps of the scanning operation. Lead 764, in turn, is connected through the spare control relay 633 (FIG. 15F), normally closed contacts, to lead 821, this latter lead being connected through normally closed contacts on strike control relay 632 to ground. Thus, the score will be added in units 604 and 605, A and B, only when the spare control and strike control relays 633 and 632, respectively, are not energized, indicating that no marks have been made.

With reference to level 601–L2, its wiper brush is connected through lead 424 and through normally open contacts on pulser relay 651 to lead 420, this lead being connected to lead 609 through player relay 641A (FIG. 14A) and to lead 610 on player relay 641B. The leads 609 and 610 are connected, respectively, to motor magnets 605A and 605B, meaning that whenever the lead 624 is energized, the motor magnet 605A or 605B will be pulsed once to add ten points to the accumulated score. The lead 624 may be pulsed during a cycle of operation of unit 601 whenever lead 423, 422 or 425 is energized. Lead 423 is connected through normally open contacts on each of the relays 618, 615 and 616 to lead 419, this lead being connected through normally open contacts on strike control relay 632 (FIG. 15F) or spare control relay 633 to lead 442 which is connected to a source of positive voltage through the tenth frame zero cycle control relay 628 (FIG. 15A). The lead 422, on the other hand, is adapted to be connected directly to lead 442 through normally open contacts on relays 615 and 618. Lead 422 is also adapted to be connected through normally open contacts on relay 616 to lead 445, the lead 445 being connected through normally closed contacts on the strike control relay 632 to lead 442. Finally, the lead 405 is adapted to be connected to lead 442 through normally open contacts on the mark doubles relay 618. Thus, a pulse will be received on lead 424 to advance the unit 605A or 605B whenever the following occur: (1) Whenever the mark double, mark spare or mark strike relay 618, 615 or 616, respectively, is energized (lead 423); (2) whenever the mark doubles relay 618 and the mark spare relay 615 are energized (lead 422); (3) whenever the mark strike relay 616 is energized and the strike control relay 632 is deenergized (lead 422); or (4) whenever the mark doubles relay 618 is energized (lead 405). Obviously, if all three leads 422, 423 and 405 are energized in response to a strike following a double, three pulses will be received on lead 424 to advance the appropriate unit 605 through thirty points. If only a double is recorded, and not followed by a mark, leads 405 and 422 will be energized to add twenty points to the previous score. In a similar manner, if a spare has been recorded, lead 422 alone will be energized, and if a strike has been made, lead 422 alone will again be energized.

Referring now to the contact level 601–L1 on unit 601, its wiper brush will make contact with lead 415 after the pulses have been transmitted to units 605. The brush on level 601–L1 is connected to lead 442 and, therefore, will be energized as long as the tenth frame zero cycle control relay 628 (FIG. 15A) is deenergized. When the brush on level 601–L1 makes contact with lead 415, a circuit is completed through this lead, contacts on pulser relay 651 and lead 416 to the pull-in coil for the score print control realy 631 (FIG. 15E). Thus, after the pulses representing pinfall are transmitted to the units 605 in the player storage assemblies, the score print relay 631 will be energized to energize the printer drive motor 113 through lead 410 and start its cycle of operation whereby the score will be printed on the score sheet. In order to print the score on the score sheet, however, the wiper brushes on the various levels of units 605A and 605B (FIGS. 14C and 14D) as well as the units 604A and 604B must be energized. From a consideration of the circuit shown in FIGS. 14A–14D, it will be noted that the wiper brushes of all of the contact levels connected to the contact points on insulating boards 196H, 196T and 196U are adapted to be connected through the player relays 641A and 641B to lead 457. The lead 457, in turn, is connected through normally closed contacts on the results print relay 629 to lead 442 which is energized through the tenth frame zero cycle control relay 628 (FIG. 15A). Therefore, as long as the results print relay 629 is not energized to break the connection between leads 457 and 442, the score print operation may occur. A score print cycle will now take place in a manner similar to the results print cycle already described.

The manner in which the various wiper brushes on the units 602A and 602B (FIG. 14B) are energized will now be described. It will be remembered that for a normal frame with no marks recorded, the wiper brushes on levels 602–A–L1 and 602–A–L4, for example, must be energized, meaning that leads 802 and 794 must be energized. Lead 802 is connected through contacts on player relay 641A to lead 482 which, in turn, is adapted to be connected through the mark zero control relay 614 (FIG. 15D) to lead 457, this same lead being connected through the results print relay 629 (FIG. 15E) to lead 442 and through contacts on zero cycle control relay 628 to a source of positive voltage. Lead 794 on level 602–A–L4 is connected through contacts on player relay 641A to lead 738 which, in turn, is connected through cable P and through normally open contacts on mark zero control relay 614 to the same lead 457.

It will be remembered that if a strike or spare is made, the wiper brush on level 602–A–L2 or 602–B–L2 should be energized. Consequently, the leads 791 and 797 are adapted to be connected to lead 485 which, in turn, is connected to the cam switch on cam 609–4 of unit 609 as well as the top switch on cam 609–2. In the position of the cams on unit 609 shown, the lead 485 will be connected to lead 483 on the cam switch associated with cam 609–2, and lead 483 is connected through normally open contacts on relays 615 and 616 (FIG. 15D) to the lead 457. Lead 457, in turn, is connected through results print relay 629 (FIG. 15E) to lead 442 and, hence, to a positive source of voltage through normally closed contacts on the tenth frame zero cycle control relay 628. Thus, the lead 485 will be energized if the cams on unit 609 are in the positions shown and with either relay 615 or 616 is energized in response to the occurrence of a strike or spare in the previous frame.

Leads 792 and 798 on levels 602–A–L3 and 602–B–L3 (FIG. 14B) are adapted to be connected to lead 486 which, in turn, is connected through cable P to unit 609, and specifically to the normally closed switch on cam 609–5. From lead 486, a circuit is completed through lead 484 which, in turn, passes through normally open

contacts on the mark doubles relay 618 (FIG. 15D) to lead 457, this lead being connected as in the previous case through the results print relay 629 and the tenth frame zero cycle control relay 628 to a source of positive voltage. Thus, the wiper brushes on levels 602–A–L3 and 602–B–L3 will be energized when, and only when, a double has been recorded.

Reverting again to the score motor 984, and particularly the cams 984–8 to 984–13, 984–15 and 984–16, it will be noted that the switches on cams 984–8 and 984–9 are each connected to a common lead 462, this lead being connected through normally closed contacts on the mark doubles relay 618 to lead 440 which is connected through cable P and the player relays 641A and 641B to leads 564 and 565. The leads 564 and 565, in turn, are connected to the motor magnets of strike-spare holding units 610A and 610B, the arrangement being such that whenever a pulse is received on lead 462 with the mark doubles relay 618 deenergized, the unit 610A or 610B will be advanced twice, depending upon which pushbutton is depressed. Furthermore, it will be noted that since cam 984–8 has two notches in its periphery whereas cam 984–9 has only one, if the lead 439 on cam 984–8 is energized two pulses will be applied; whereas if lead 438 on cam 984–9 is energized only one pulse will be received on lead 462. The lead 439 associated with cam 984–9 is adapted to be connected through normally open contacts on the strike control relay 632 (FIG. 15F) to lead 442 which, in turn, is connected to a source of positive voltage through the zero cycle control relay 628 (FIG. 15A). The lead 438, on the other hand, is adapted to be connected to lead 442 through normally open contacts on the spare control relay 633. Thus, if a strike is to be recorded and the strike control relay 632 energized, the lead 438 will be energized whereby two pulses will appear on lead 462. If, on the other hand, a spare is to be recorded, and the spare control relay 633 energized, the lead 438 will be energized to pulse lead 462 only once.

With reference now to cams 984–10 and 981–11 (FIG. 15E), the switches on these cams are each connected to a common lead 437 connected through normally open contacts on tenth frame relay 613 (FIG. 15D) to lead 864 which, in turn, is connected through normally open contacts on tenth frame relay 611 to lead 865. The lead 865, in turn, is connected to the motor magnet for the tenth frame ball counter 609 (FIG. 15C), the arrangement being such that in the tenth frame when both of the relays 611 and 613 are energized, and the lead 437 also energized, the tenth frame ball counter 609 will be advanced. The lead 437 may be energized upon closure of the switches on cam 984–10 or 984–11 by energization of lead 436 or 435, respectively. Lead 436 is energized by closure of normally open contacts on the first ball relay 634 (FIG. 15F). That is, when relay 634 is energized, lead 436 will be connected to lead 415 which is energized during the tenth frame in a manner hereinafter described. The lead 435, on the other hand, is adapted to be connected to lead 415 through normally open contacts on the second ball latch relay 635. Thus, when the first ball is rolled and relay 634 is energized, lead 436 will be energized to pulse unit 609 once; whereas when the second ball is rolled in the tenth frame, relay 635 will be energized as well as the relay 634 to pulse the unit 609 twice.

Referring now to the cam 984–12, when it closes it connects a source of positive voltage to lead 866 which, in turn, is connected through normally closed contacts on the tenth frame relay 613 to lead 431. The lead 431 is connected through cable P and through player relay 641A or 641B to lead 432 or 433 to pulse the appropriate frame unit 602. Furthermore, this occurs each time the score motor cycles once, provided that tenth frame relay 613 is not energized.

With reference to cam 984–13, it will connect lead 426 to a source of positive voltage, and lead 426 is connected to lead 433 through the normally closed contacts of tenth frame relay 613. The lead 433, in turn, energizes solenoid 974 shown in FIG. 14A to release all pushbuttons, and this occurs at the completion of the cycle of score motor 984, but not necessarily in the tenth frame.

With reference now to cam 984–16, when 280° of travel of the score motor 984 is reached, the switch on cam 984–16 will connect lead 496 to a source of positive voltage. The lead 496, in turn, is adapted to be connected through a cam switch on cam 603–C for stepping unit 603 (FIG. 15C) to the motor magnet for unit 603, thereby pulsing this unit until it reaches its home position where the circuit is broken between lead 496 and the motor magnet and made between leads 496 and 495. Lead 495 is then connected through a switch on cam 607–C on the unit 607 (FIG. 15B), and this unit is homed out (i.e., returned to its starting position shown) in the same manner as unit 603 until the cam switch is reversed to connect lead 495 to lead 480, whereupon the unit 606 is homed out. In this manner, all of the units 606, 607 and 603 are returned to their initial starting positions at the end of the cycle of the score motor.

When the cam switch on cam 984–16 closes, it also connects lead 831 to a positive source of voltage, and lead 831 is connected through normally open contacts on the tenth frame zero cycle control relay 628 (FIG. 15A) to lead 487 which, in turn, is connected to a cam switch on cam 609–5 (FIG. 15C), which cam switch is closed when the unit is off normal so that the lead 487 is connected to the motor magnet for unit 609 to home it out.

Advancement of Printer Tape

It will be remembered that the printer tape 248 (FIG. 8) is advanced when solenoid 264 is energized. This solenoid is shown in FIG. 15F and is connected to lead 867 which, in turn, is connected to the cam switch on cam 984–12 (FIG. 15E). Thus, the tape will be advanced each time the score motor 984 cycles.

Homing of Strike-Spare Holding Units

It will be noted in FIG. 14A that a normally open cam switch on cam 610–A–3 or on cam 610–B–3 is connected through lead 564 or 502 and the player relays 641A and 641B to lead 456. The lead 456, in turn, is connected through cable P to normally open contacts on relay 624 (FIG. 15F), the arrangement being such that the lead 456 will be energized and the units 610A and 610B homed out when relay 624 is energized. This relay is energized through lead 519, which, in turn, is connected to lead 404 on mark double relay 618 (FIG. 15D). Lead 404, in turn, is connected to lead 465 through normally open contacts on relay 631 and thence to the cam switch on cam 288–3. Thus, the strike-spare holding units will be homed out at the completion of a score print cycle if no double is recorded. On the other hand, if a double is recorded and no strike made with the first ball, lead 404 will be connected to lead 526 which, in turn, is connected through normally closed contacts of strike control relay 632 to lead 440. The lead 440 is connected through cable P to the relays 641A and 641B (FIG. 14A) and thence through lead 564 or 565 to advance the unit 610A or 610B to the fifth position, whereupon the lead 460 will become energized to energize relay 616 to indicate that only a strike, rather than double, is now recorded. The relay 624 is reset or pulled out by energization of lead 466 on cam 288–2 (FIG. 15E) at the completion of a printing cycle.

Prevention of Strike or Spare Being Achieved When Gutter Ball or Foul Occurs

With reference, now to relay 652 (FIG. 15F), it is energized through lead 525 which, in turn, is connected to the tenth contact on levels 606–L1 and 607–L1 of units 606 and 607 (FIG. 15B). This contact will be reached when a full standing ten pins is counted by either the unit

606 or 607. When this occurs and lead 525 is energized, relay 625 will pull in to disconnect leads 557 and 490. The lead 557 is connected through normally open contacts on relay 629 (FIG. 15E) to lead 547 which, in turn, is connected through relays 639 and 640 (FIG. 15A) to a source of positive voltage. The lead 490, on the other hand, is adapted to be connected through normally closed contacts on cam 606–C (FIG. 15B) to lead 530 or through normally open contacts on cam 606–C, lead 459 and normally closed contacts on cam 607–C to the same lead 530. Lead 530, in turn, is connected through normally closed contacts on relay 635 to lead 498 which is connected to the pull-in coil for strike control relay 632. On the second ball, the lead 530 is connected to the pull-in coil for spare control relay 633. Thus, before a strike or spare can be recorded, the relay 652 must be deenergized, meaning that neither a foul nor gutter ball has occurred.

Scoring of Normal Frame—No Marks Made or Recorded

Specific scoring situations which occur during a bowling game will now be considered. Each time a bowler prepares to bowl, he will push his appropriate pushbutton switch A or B, thereby energizing the corresponding player switch 641A or 641B. When this occurs, the master circuit shown in FIGS. 15A–15F is connected to that player's particular frame unit shown in FIG. 14B as well as his score totalizing and storage units shown in FIGS. 14D and 14C and also his strike-spare holding unit shown in FIG. 14A. As soon as a player pushbutton is depressed, the printing wheels are directed to the proper player line and the proper frame in the manner described above. If the league play switch 922 is not closed, the alley connecting relay 619 will be energized to connect the standing pin detector, as well as the foul detector and gutter detector and other associated circuitry of a single alley, to the master circuit. On the other hand, if the league play switch 922 is closed, the alley connecting relays 619 and 620 will be energized alternately to alternately connect the standing pin detector, the foul detector, the gutter detector and other associated circuitry of two adjacent alleys to the master circuit. For purposes of the present description, we will assume that the switch 922 is open and that the alley connecting relay 619 is permanently energized.

When the bowler delivers the first ball and it strikes the backstop, the limit switch 978 (FIG. 15A) will be closed to energize relay 644. When relay 644 pulls in, the timer motor 975 (FIG. 15B) will be energized to start a cycle of rotation; and, at the same time, the lead 722 will be energized to enable the standing pins to be detected. At 135° of rotation of the timer motor 975, the control circuit 979 will energize motor 930 to sweep the coils 926–929 across the tops of the pins; and as these coils are swept across the tops of the pins momentary pulses will be induced in leads 718–721 which are used to actuate the standing pin registers 701–704. The registers 701–704 convert the momentary pulses on leads 718–721 into seady-state signals on leads 570–580 (FIG. 15B), the number of signals corresponding to the number of standing pins. At 250° of revolution of the timer motor 975, the reset coil of relay 644 (FIG. 15A) is energized, and lead 724 is energized from lead 561 to energize lead 509 through the contacts of relay 619. When lead 509 is energized it, in turn, initially pulses the pulse generating relay 621 which, in turn, drives the stepping unit 608 through a complete revolution, the result being that a number of pulses will appear on lead 518 corresponding to the number of standing pins. These pulses are applied through contacts on pulse generating relay 621 to lead 521 which is connected through relay 635 (FIG. 15F) to lead 492. Lead 492, in turn, pulses unit 606 to advance this unit a number of times corresponding to the number of standing pins. The unit 606, as was explained above, converts the number of standing pins into the number of fallen pins by electrically subtracting the number of standing pins from ten. Thus, a number of contacts on level 608–L3 of unit 608 will be energized corresponding to the fallen pins and these are applied through lead 517 and lead 516 to the motor magnet for unit 603 (FIG. 15C) and also through relay 635 (FIG. 15F) and lead 493 to stepping unit 607, the purpose of unit 607 (FIG. 15B) being to subtract the number of fallen pins from ten to establish the number of standing pins for the second ball rolled.

At the beginning of the cycle of unit 608 after delivery of the first ball, the first ball relay 634 (FIG. 15F) is pulled in by energization of lead 512 on cam 608–C of unit 608. At the end of the cycle of unit 608, lead 513 is energized which, in turn, energizes the results print relay 629 (FIG. 15E). When relay 629 is energized, lead 410 is connected to a source of positive voltage, thereby energizing the printer drive motor 118 which causes a printing cycle to print the ball results of the first ball. At the completion of the cycle of the printer drive motor 118, the cam 288–3 will connect lead 406 to a source of positive voltage, and this lead will now be connected through results print relay 629 to lead 454, thereby energizing score motor control relay 630 (FIG. 15A). When relay 630 is energized, lead 441 is energized to energize the score motor 984; and since the mark zero relay 613 is now closed, the score motor 984 will rotate through 180° in the manner described above.

The circuit is now ready for the second ball. After the second ball is delivered, the process described above with respect to the first ball is repeated, except that in this case relay 635 (FIG. 15F) is energized so that the lead 521 from pulsing relay 621 is now connected to lead 493 which, in turn, pulses the second ball stepping unit 607 to advance its wiper brushes in an amount corresponding to the number of pins standing after the second ball. In this process, the wiper brush on level 607–L1 will be on the contact corresponding to the number of pins knocked down by the second ball. All of this occurs before the unit 608 completes its cycle, and when it completes its cycle it will again contact lead 513 which again energizes the results print relay 629 to actuate the printer drive motor 118 and print the results of the second ball. Again, at the completion of the cycle of operation of the printer drive motor 118, the lead 406 will be again energized, and since the results print relay 629 is energized it will be connected to lead 454 which energizes the score motor control relay 630 as in the case of the first ball cycle. When relay 630 closes, the score motor 984 is again energized and will rotate from 180° to 270° and stop by virtue of the fact that relay 614 is now energized. As the score motor 984 rotated from 180° to 270°, the switch on cam 984–3 was closed momentarily to energize, through lead 545, the pulse generator 651 which steps its stepping unit 601 to read-off the energized leads on level 601–L4. The resulting pulses on the wiper brush of level 601–L4, corresponding to the total frame pinfall, is then transferred through lead 421, stepping relay 651 and lead 449 to the player relay 641A or 641B. From this relay the pulses on lead 449 are, for player A, for example, transferred to lead 625 to step up storage unit 604A. At the end of the cycle of stepping unit 601, the wiper brush on level 601–L1 contacts lead 415 which is connected through stepping relay 615 to lead 416. The lead 416, in turn, is connected to the pull-in coil for score print relay 631. Thus, when relay 631 is energized, lead 410 is connected to a source of positive voltage, thereby again actuating the printer drive motor 118 which now prints the score totalized to this point. Since lead 457 is now energized through contacts on results print relay 629, all of the wiper brushes on the units 604 and 605 will be energized through the appropriate player relay 641A or 641B. When the printer drive motor 118 cycles to print the score, lead 466 will again be energized at the completion of the cycle of the printer drive motor to energize

the pull-out coil for score print relay **621** and relay **624**. In this process, the score motor control relay **630** is energized through lead **456** to energize the score motor **984** which now rotates from 270° to 360° and stops. In this process, lead **428** is energized on cam **984–7** (FIG. 15D) to reset all of the relays **632**, **635**, **633** and **634** of FIG. 15F.

Thus, in normal frame play with no previous marks recorded and with no marks made during the frame, the timer motor **975** will cycle twice, the printer drive motor **118** will cycle three times, and the score motor **984** will cycle once through 360°.

No Previous Marks—Spare Made With Second Ball

Let us assume, now, that there are no previous marks recorded and that a spare is made by knocking down ten pins with the second ball. Under these circumstances, the second ball control relay **635** will have its contacts reversed respective to the positions shown, and when unit **603** is advanced through ten positions due to the fact that ten pins have been knocked down, the lead **530** is energized which, in turn, is connected through normally open contacts of second ball latch relay **635** (FIG. 15F), which is now pulled in as we are in a second ball cycle, to the lead **497**. The lead **497**, in turn, is connected to the pull-in coil for spare control relay **633**.

When relay **633** is thus energized, it connects lead **438** to lead **442** which is now energized since the zero cycle control relay **628** (FIG. 15A) is now deenergized. The lead **438**, in turn, is adapted to be connected through the cam switch on cam **984–9** (FIG. 15D) to lead **462**. The lead **462** is connected through normally closed contacts on the mark double relay **618** to lead **440** which, in turn, is connected through relay **641A** or **641B** (FIG. 14A) to the motor magnet for unit **610A** or **610B**. Thus, when the cam switch on cam **984–9** closes at 190° of travel of the score motor, the appropriate unit **610A** or **610B** is pulsed once to record the occurrence of the spare in the manner described aobve. When a spare has been made, the score motor **984** will rotate from its 180° position to its 360° position without stopping by virtue of the fact that the lead **448** will no longer be connected to lead **445**. When lead **448** is deenergized, the lead **430** connected to the cam switch on cam **984–6** (FIG. 15D) will also be deenergized so that the lead **409** will not be energized at 270° of rotation of the score motor to energize the pull-out coil for the score motor control relay **630** as shown in FIG. 15A. Thus, when a spare is made with the second ball with no previous marks recorded, the appropriate strike-spare holding unit **610** (FIG. 14A) will be pulsed once and the score motor will rotate from 180° to 360° without stopping.

No Previous Marks—Strike Made With First Ball

If all ten pins are knocked down with the first ball rolled, the unit **606** (FIG. 15B) will not advance, and when the results print relay **629** is energized through lead **513** at the completion of a cycle of unit **608**, the lead **547** which is energized through normally closed contacts on relays **639** and **640** (FIG. 15A) is connected to lead **557**. The lead **557**, in turn, will be connected to lead **490** on relay **652** (FIG. 15F) if neither a foul nor gutter ball condition exists. The lead **490**, in turn, is connected through a normally closed cam switch on cam **606–C** of unit **606** (FIG. 15B) to lead **530** which is connected through normally closed contacts on the second ball latch relay **635** (FIG. 15F), which is now deenergized since we are in a first ball cycle, to lead **498** which is connected to the pull-in coil for strike control relay **632**. Thus, the strike control relay **632** is pulled in to connect the lead **442** to lead **439**. The lead **439**, in turn, is adapted to be connected through the switch on cam **984–8** (FIG. 15D) to lead **462** which is connected through normally closed contacts on mark double relay **618** to lead **440**, this latter lead being connected to the appropriate motor magnet for the strike-spare holding unit **610A** or **610B** (FIG. 14A). It will be noted that the cam **984–8** (FIG. 15D) has two notches therein spaced closely following the 180° mark. Thus, as the score motor rotates from 180° to 270°, two pulses will be induced in leads **462** and **440** to advance the appropriate strike-spare holding unit twice. Again, the score motor **984** will rotate from 180° to 360° without stopping since the lead **448** will now be deenergized by virtue of opening of the contacts between leads **445** and **442** on relay **632**, thereby deenergizing the lead **430** which cannot energize lead **409** to pull out the score motor control relay **630** at 270° of revolution.

Scoring of a Spare After the First Ball of the Following Frame

When a spare has been made in the frame previous to the frame being played, the appropriate strike-spare holding unit **610A** or **610B** will have been advanced once to energize lead **459**, thereby energizing the spare control relay **615** (FIG. 15D). Now, when the first ball is rolled, the results print relay **629** is energized, and at the completion of the results print cycle, the score motor **984** is energized in the manner described above. When the score motor reaches 85° of revolution, the cam **984–4** will connect lead **413** to lead **409**. The lead **413**, in turn, is now connected through normally open contacts on mark spare relay **615** to lead **442** which is now energized through the tenth frame zero cycle control relay **628**. Thus, the lead **409** will be pulsed at this time to deenergize or pull out the score motor control relay **630** (FIG. 15A) to stop the score motor **984** at 90° of revolution.

In rotating from 0° to 90°, the cam switch on cam **984–1** was momentarily closed, thereby connecting lead **444** to lead **545**. The lead **444** is connected now through normally open contacts on mark spare relay **615** to the lead **442** which is energized through the tenth frame zero cycle control relay **628** (FIG. 15A). Thus, the lead **545** is energized at 90° of revolution of the score motor to pulse the unit **651**, thereby advancing the unit **601** which will now produce a number of pulses in lead **421** corresponding to the number of pins knocked down by the first ball in the frame being played. When the wiper brush on level **601–L2** of unit **601** reaches the contact point connected to lead **422**, a pulse will be induced in lead **424** by virtue of the fact that lead **422** is now connected to lead **442** through mark spare relay **615**. The lead **424**, in turn, is connected to lead **420** which, in turn, is connected through player cable P and the appropriate player relay **641A** or **641B** to the motor magnet for the appropriate tens unit **605A** or **605B**, thereby stepping this unit once to account for the ten pins knocked down in the previous frame.

It can thus be seen that at this point with the score motor having rotated to the 90° position, the total pinfall of the first ball in the frame following a spare plus the tens pins knocked down in the previous frame have been scored in that previous frame.

When unit **601** completes its cycle and the wiper brush on level **601–L1** contacts lead **415'**, the lead **416** is pulsed to pull in the score print relay **631**, thereby energizing the printer drive motor **118** which prints the score in the frame previous to the frame being played where the spare occurred. At the completion of the cycle of the printer drive motor **118**, two things happen: First, the relay **624** is energized through lead **519** connected to lead **404** on relay **618** thereby homing out the appropriate strike-spare holding unit **610A** or **610B** to erase or remove the spare recorded thereon. Second, lead **406** on cam **288–3** is energized momentarily to energize lead **418** which, in turn, is connected through normally closed contacts on mark strike relay **616** to lead **454**, this lead serving to energize the score motor control relay **630** (FIG. 15A) and rotate the score motor

984 from 90° to 180°. At 175° of rotation, the lead 445 is connected to lead 409, and the lead 445, in turn, is connected through normally closed contacts on relay 632 to lead 442 which is now energized. Thus, the score motor 984 will stop at 180°.

We are now ready for the second ball which will actuate the circuitry as described above for a normal frame with no marks made or for a spare condition as previously described.

Scoring of a Frame Following a Recorded Strike

If a strike is recorded on the strike-spare holding unit 610A or 610B, the mark strike relay 616 will be energized when the appropriate player pushbutton is energized. Now, when the first ball is rolled and the results printed, the score motor 984 will again be energized at the completion of the cycle of the printer drive motor 118, but since lead 413 is now energized from lead 445, the lead 409 will be energized at about 85° of rotation of the score motor 984 to stop the score motor at 90°. No scoring, however, will occur at this point.

When the second ball is rolled, the results print relay 629 will again be energized to rotate the printer drive motor 118 to print the results of the second ball. At the completion of the cycle of the printer motor 118, the score motor 984 is again energized, but now the lead 425 will be energized through contacts on mark strike relay 616 which connects lead 425 to lead 445, this lead being connected through strike control relay 632 to lead 442 which is now energized. At about 100° of rotation of the score motor 984 the lead 425 will energize lead 545 to initiate the pulse generating relay 651 which causes the unit 601 to step through ten positions. As the unit 601 steps, pulses will be induced in lead 421 corresponding to the number of pins knocked down by the first and second balls in the frame being played and applied to the appropriate unit 604A or 604B. At the same time, when the wiper brush on level 601–L2 reaches the contact to which lead 422 is connected, its wiper brush will be pulsed. That is, the lead 422 will now be connected through the mark strike relay 616 to lead 445 which is now connected through the strike control relay 632 to lead 442. Thus, the lead 424 connected to the wiper brush on level 601–L2 is pulsed to pulse the appropriate tens unit 605A or 605B. As the score motor 984 rotated from 90° to 180°, the score print relay 631 was energized through lead 416 which was pulsed through relay 651 connected to lead 415, this latter lead being energized at the completion of the cycle of unit 601. Thus, the score print cycle will be achieved after the rolling of the second ball following a strike to print the accumulated score in the frame preceding the frame being played. Relay 624 will again be energized as in the case of a spare to erase the strike recorded on unit 610A or 610B. At the completion of the cycle of the printer drive motor 118, the lead 418 will be energized from lead 406, and the lead 418 is, in turn, connected through normally closed contacts on the mark strike relay 616 to lead 454 The lead 454, in turn, pulls in the score motor control relay 630 to rotate the score motor 984 from 180° to 270° where it stops due to the fact that the lead 430 on cam 984–6 will now be energized since relay 614 is now energized while relays 632 and 633 are deenergized.

In traveling from 180° to 270°, the switch on cam 984–3 connects lead 417 to lead 545. The lead 417 is now energized through lead 448 since relays 632 and 633 are now deenergized. Consequently, the pulse generating relay 651 will be energized to step the unit 601 whereby the pinfall results of the first and second balls of the frame being played are applied to the appropriate player relay 641 or 641B to the appropriate units unit 604A or 604B.

Scoring in Frame Following a Double

If a double has been achieved, the appropriate strike-spare holding unit 610A or 610B (FIG. 14A) will energize the mark double relay 613. Now, when the first ball is rolled and the results print cycle is completed, the score motor will cycle to 90°, and since the leads 422 and 405 on level 601–L2 will both be energized at this time since the mark double relay 613 is now closed, two pulses will be applied via leads 424 and 429 and through the appropriate player relay 641A or 641B to the tens unit 605A or 605B to advance this unit twice and add twenty points to the score. Thereafter, the score printing cycle occurs and one strike is erased in the manner described above. That is, lead 404 will now be connected to lead 526 which, in turn, is connected through normally closed contacts on strike control relay 632 to lead 440. The lead 440 is connected through cable P to the relays 641A and 641B (FIG. 14A) and thence to lead 564 or 565 to advance the unit 610A or 610B to the fifth position, whereupon the lead 460 will become energized to energize relay 616 to indicate that only a strike, rather than a double, is now recorded. With the strike now recorded, scoring proceeds as in the case of a strike previously described.

Tenth Frame

When the tenth frame is reached, the wiper brush on level 602–A–L6 or 602–B–L6 will reach the tenth position, whereupon the lead 403 will be energized. This lead, in turn, is connected through cable P to tenth frame relay 611 to energize the same. When the relay 611 is energized, the lead 401 will be connected to a source of positive voltage, this lead 401 being connected through normally open contacts on the mark strike, mark spare, and mark double relay 616, 615 and 618, respectively, to lead 415. Lead 415, in turn, energizes tenth frame relay 613. In other words, the relay 611 will always be energized in the tenth frame; whereas the relay 613 will be energized in the tenth frame only if there are marks recorded on the strike-spare holding unit 610A or 610B in FIG. 14A.

With reference to the tenth frame ball counting unit 609 as shown in FIG. 15C, it will be noted that it is energized through lead 865 which, in turn, is connected through normally open contacts on tenth frame relay 611 (FIG. 15D) to lead 864 which is connected through normally open contacts on relay 613 to lead 426. Each time the unit 609 is pulsed or energized, its cams 609–1 to 609–5 rotate in a clockwise direction through 90°. Since the relay 613 will be energized only if there is a recorded mark at this time, the unit 609 will be pulsed or advanced to count the balls in the tenth frame only if a mark is made with the first or second ball in the tenth frame. Otherwise, the tenth frame proceeds as any other frame.

The lead 437, it will be noted, is connected to the cam switches on cams 984–10 and 984–11 (FIG. 15E). The lead 437 may thus be energized through lead 436 or 435. Lead 435 is adapted to be connected through normally open contacts on relay 635 (FIG. 15F) to lead 415. Lead 415, in turn, will now be energized if one of the mark control relays 613, 615 or 616 is energized. If a strike was rolled, the first ball latch 634 will be closed, and the mark strike relay 616 would have been closed before cam 984–10 reaches its notch to connect lead 436 to lead 437. Therefore, a pulse will be induced in lead 437 to pulse lead 865 and advance the unit 609 once. On the other hand, if a spare was made with the first two balls in the tenth frame, both the first and second ball latch relays 634 and 635 would be closed, thereby energizing both of the leads 436 and 435 such that when the score motor 984 rotates from 180° to 270° two pulses will be induced on lead 865 to advance the ball counting unit 609 twice.

The unit 609 controls three functions: First, it controls the energization of the index solenoids 186F, 186S and 186B (FIG. 15C). Second, it controls the positioning of

the printing wheels with respect to the frame which they should be positioned under; and third, it controls energization of the tenth frame zero cycle control relay **628** (FIG. 15A).

If, for example, a strike is made with the first ball in the tenth frame, a unit **609** will be advanced once after the results printing cycle, thereby disconnecting lead **471** from lead **469**. At the same time, the lead **472** on the second ball results printing unit will be connected on the bottom cam **609–1** to lead **469**. In addition, the lead **473** on the bonus ball results printing unit (FIG. 15C) will be connected to lead **470** on the bottom cam **609–1**. As we are now in a first ball cycle, the lead **635** (FIG. 15F) will be deenergized, meaning that the lead **469** is now connected to lead **463**, this latter lead being connected through the cam switch on cam **288–5** (FIG. 15E) to ground. The lead **470** at this time, however, cannot be connected to lead **463** on relay **635** since there are open contacts between the leads **470** and **463** at this time (i.e., a first ball cycle). When the third ball in the tenth frame is delivered, however, the relay **635** will then be energized so that lead **470** will be connected to lead **463** to energize lead **473** which is connected to the index solenoid for the bonus ball results printing unit.

If two successive strikes are made with the first two balls in the tenth frame, the unit **609** will be advanced twice rather than once, however from a consideration of the unit **609** it will be seen that on the second ball the lead **472** will be energized and on the third ball the lead **473** will be energized.

The same situation exists for a spare. That is, if a spare is made with the first two balls in the tenth frame, unit **609** is advanced twice whereby the lead **472** will be energized on the second ball and the lead **473** energized on the third.

It will be remembered that in normal frame play when a strike or spare is recorded and relay **615** or **616** is energized, the lead **485** will be energized (FIG. 14A) to cause the printing wheels to move backwardly during a score printing operation. Similarly, when a double is recorded and the relay **618** energized, the lead **486** was energized to cause the printing wheels to move backwardly through two frames. The leads **485** and **486** are both connected through the unit **609**, the arrangement being such that when the unit **609** is advanced once in response to a strike made with the first ball of the tenth frame, the lead **486** will then be disconnected from lead **484** on the mark double relay **618**. At the same time, the lead **485** which, when energized, causes the printing wheels to move back one space, will be energized through lead **484**. In other words, under the conditions just described, the printing wheels will now move back one space, rather than two, upon rolling of the second ball in the tenth frame. If, for example, a double was recorded when the first ball of the tenth frame is rolled, scoring occurs as in normal frame play wherein the printing wheels move back two frames.

If a strike is made with the second ball, the unit **609** will be advanced one more time, thereby disconnecting both of the leads **486** and **485** from lead **484**, the result being that the printing wheels will now remain in the tenth frame. The same condition applies for a spare. That is, if a spare is made in the tenth frame with the second ball rolled, the printing wheels will not move backwardly to the preceding frames as in normal frame play but rather will remain in the tenth frame.

Referring now to the tenth frame zero cycle control relay **628** (FIG. 15A), the purpose of this relay is to return the score motor **984** to its home position in the tenth frame following a bonus ball and also to disable the scoring circuitry in the master circuit when a particular bowler has completed the tenth frame and his player pushbutton is depressed. This is accomplished by disconnecting the lead **442** from its source of positive voltage, and from a consideration of the circuitry already described, it will be seen that deenergization of this lead will prevent any further scoring.

The relay **628** is energized or pulled in by energization of lead **478**. The lead **478** is adapted to be connected through normally open contacts on second ball latch relay **635** (FIG. 15F) to lead **476**. Alternatively, it can be connected through normally open contacts on the first ball latch relay **634** to lead **477**. The relay **635** will be energized by the third ball of the tenth frame if a strike was rolled with the first ball. Thus, under these conditions, lead **478** will be connected to lead **476** which, in turn, is connected through a cam switch on cam **609–1**, which is now closed, to lead **427**. The lead **427**, in turn, is connected through contacts on relay **611** (FIG. 15D), which are now closed, to lead **404**. Lead **404** is connected (FIG. 15A) through normally open contacts on score print relay **621** to lead **465** which, in turn, will be energized at the completion of a score printing cycle of the printer drive motor **118**. In other words, after the bonus ball in the tenth frame, and after the score has been totalized and printed in this, the tenth frame, the relay **628** will be pulled in to prevent any further scoring. When relay **628** is thus pulled in, the lead **454** is also energized from a source of positive voltage. The lead **454**, in turn, is connected to the energizing or pull-in coil for the score motor control relay **630**, the arrangement being such that the score motor will be cause to rotate to its home position.

When relay **628** is energized, it also connects lead **831** to lead **487** as shown. Lead **487** will now be connected to the energizing coil for unit **609** through its normally closed contacts **609–C**; whereas the lead **831** is connected to a source of positive voltage on score motor cam **984–16** (FIG. 15E) when the score motor rotates from 280° to 320°. Thus, as the score motor **984** is rotated to its home position, the lead **831** will be energized which, through the contacts of relay **628**, which are now closed, will cause the unit **609** to be homed or also driven to its initial starting position. Just before the score motor **984** reaches its home position at 355°, it will energize lead **428** on cam **984–7**. The lead **428**, in turn, is connected to the deenergizing or pull-out coil for relay **628**, thereby preparing this relay for another operation.

Homing of Storage Units at the Completion of a Game

With reference to FIG. 14B, it will be noted that a limit switch **986** is provided, this limit switch being adapted to be contacted by the carriage **64** (FIG. 3) when the printing wheels move off the first frame. When the printing wheels are in the first frame, the limit switch **986** will be in the position shown whereby lead **434** will be connected to a source of positive voltage. Lead **434**, in turn, is connected to the reset coil of reset relay **636** (FIG. 15E) to maintain the contacts of this relay in an open position. By the time the printing wheels have moved to the second frame, however, at least one of the frame units **602A** or **602B** will have moved off normal, thereby opening the upper contacts on its cam **602A–C** or **602B–C**. When, however, a game is completed and all of the units **602A**, **602B**, and so on, have returned to normal (i.e., have been stepped ten times), the upper contacts on their cam switches will close, thereby completing a circuit from limit switch **986**, which is now closed, to lead **527**. The lead **527**, in turn, is connected to the pull-in coil of reset relay **636** (FIG. 15A) whereby all of its contacts will close. The pull-in contacts on reset relay **636** are connected to a source of positive voltage. The other sides of the contacts are all connected to various stepping units in the player storage circuitry of FIGS. 14A–14D to advance all of the stepping units to home position. Thus, lead **488** on relay **636** is connected (FIG. 14C) to the cam switch on cam **604A–C**, thereby homing out units **604A** and **604B** in succession, the cam switch on unit **604A** being connected to that on unit **604B** through lead **494**. The

units **605** shown in FIGS. 14C and 14D are homed out through lead **524** which is connected to the cam switch on cam **605B–C**, this cam switch being connected to the cam switch **605A–C** through lead **528**. The unit **610A** is homed out through lead **501** on relay **636** which is connected to the top contact on the cam switch for cam **610–A–3**. In a similar manner, unit **610B** is homed out through lead **502** and relay **636**.

Printing Indication of a Split on Score Sheet

When a split occurs after the rolling of the first ball in a frame, it is desirable to indicate its existence on the score sheet. For this purpose, a contact on the insulating board **196U** (marked "S") in FIG. 14D is connected to lead **990** which, in turn, is connected through cable P (FIG. 14C) to normally open contacts on relay **991** (FIG. 15E). The pull-in coil for relay **991** is connected through lead **992** and a pushbutton **993** to normally closed contacts of a cam switch on cam **984–15** (FIG. 15E). The other side of these contacts is connected through lead **547** and relays **639** and **640** (FIG. 15A) to a source of positive voltage. Thus, the lead **992** and relay **991** can be energized only in the absence of a foul or gutter ball condition when both of the relays **639** and **640** are in the positions shown.

The lead **990** is adapted to be connected through the normally open contacts of relay **991** (FIG. 15E) to lead **557**, this latter lead being energized in the manner described above when relay **629** is energized during a results print cycle.

Let us assume, for example, that a split has occurred after the rolling of the first ball. Under these conditions, the top switch on cam **984–15** will be closed, and when the pushbutton **993** is manually depressed by the player, relay **991** will pull-in to energize lead **990**. Since we are now in a results print cycle, the printing wheel **134** will be stopped at the "S" contact (FIG. 14D) to print an "S" adjacent the score boxes in the frame being played. This is accomplished by offsetting the "S" printing character on printing wheel **134** so that it prints in line with the results boxes rather than in the center of the score boxes just as the printing characters on the results printing wheels **136**, **138** and **140** are offset so that they will print in the results boxes.

Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention.

We claim as our invention:

1. In combination with apparatus for automatically registering and totalizing the score for a bowling game, the improvement comprising substantially flat and transparent plate means, a score sheet divided into frame score spaces, said score sheet being formed of material which will permit light to pass therethrough and supported in close abutting relationship with said transparent plate means such that substantially the entire sheet is visible during the progress of a bowling game and the score sheet can be illuminated by light passing through the transparent plate means, means for registering the number of pins knocked down after each ball is rolled in a game, means responsive to said registering means for tabuling the accumulated score for each frame in a normal ten frame game, and means located adjacent said score sheet on the side thereof opposite the transparent plate and responsive to said tabulating means for printing the accumulated score in successive score spaces on the score sheet.

2. In apparatus for automatically registering and totalizing the score for a bowling game, the combination of means for registering the number of pins knocked down after each ball is delivered in a bowling game, means responsive to said registering means for tabulating the accumulated score for each frame in a normal ten frame game, substantially flat and transparent plate means, a bowling game score sheet having frame score spaces provided thereon along player lines, said score sheet being formed of material which will permit light to pass therethrough and supported in close abutting relationship with said transparent plate means such that substantially the entire sheet is visible during the progress of a bowling game and the score sheet can be illuminated by light passing through the transparent plate means, printing apparatus positioned adjacent the score sheet on the side thereof opposite the transparent plate and operable in response to said tabulating means for printing the accumulated score in successive score spaces along the player lines on the score sheet, a motor device for producing relative movement between the score sheet and the printing apparatus whereby the printing apparatus may be positioned adjacent successive score spaces as the game progresses, circuit means responsive to said registering means for recording the number of frames played in a game, and apparatus coupled to said circuit means and operable at the completion of a frame for actuating said motor device to produce relative movement between the score sheet and the printing apparatus whereby the printing apparatus will be adjacent the score space succeeding the score space for the last frame played.

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