

[54] PIN SENSING SYSTEM

3,309,086 3/1967 Viets et al. 273/54

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[21] Appl. No.: 224,245

Related U.S. Application Data

[62] Division of Ser. No. 44,733, June 9, 1970, Pat. No. 3,705,722.

[52] U.S. Cl. 273/54 E, 250/222 R

[51] Int. Cl. A63d 5/04

[58] Field of Search 273/54 E; 250/222 R, 234

[56] References Cited

UNITED STATES PATENTS

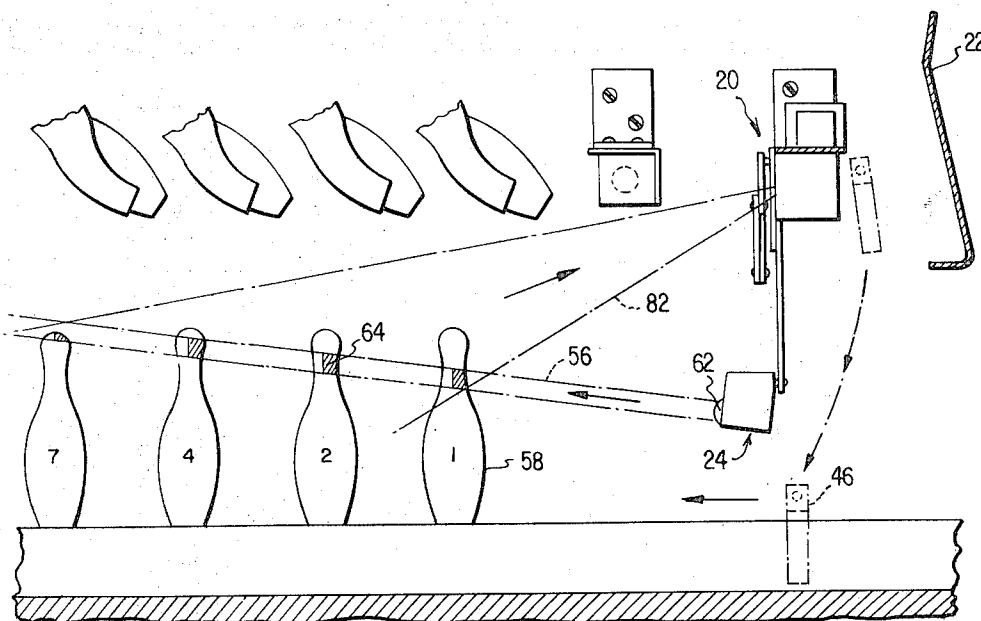
2,980,424 4/1961 Sanders et al. 273/54 E X

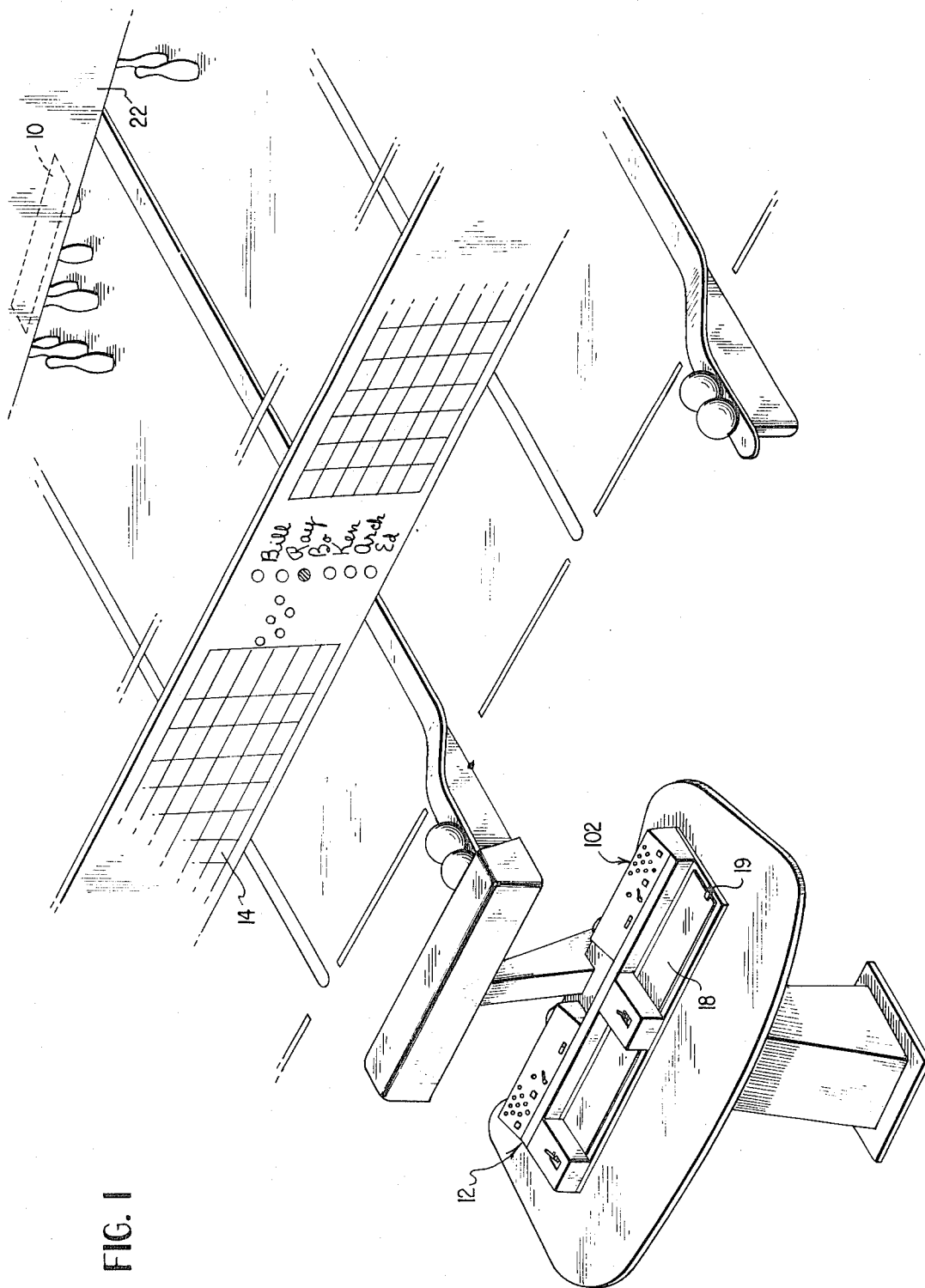
Primary Examiner—Anton O. Oechsle
Attorney, Agent, or Firm—Colton & Stone, Inc.

[57] ABSTRACT

A pin sensing system, based on the definition of pin sensing zones by intersecting reflecting and transmitting optical paths, transmits "pins standing" information to distinct optical projection and data printing systems. The intersecting, reflecting and transmitting optical paths originate in front of the head pin position and converge in the direction of the pit end of the lane.

4 Claims, 40 Drawing Figures





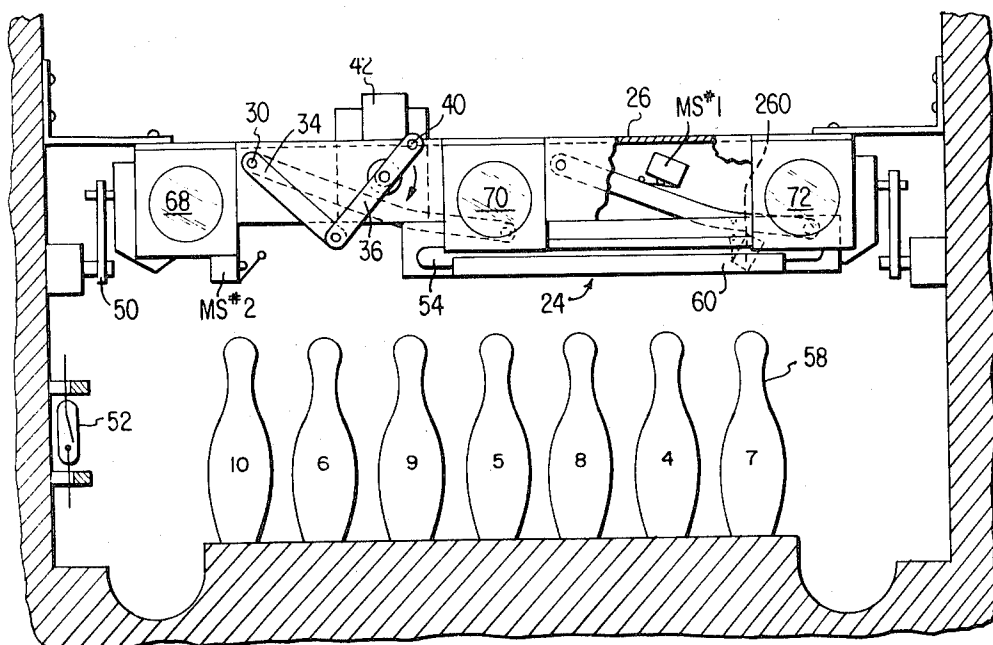


FIG. 2

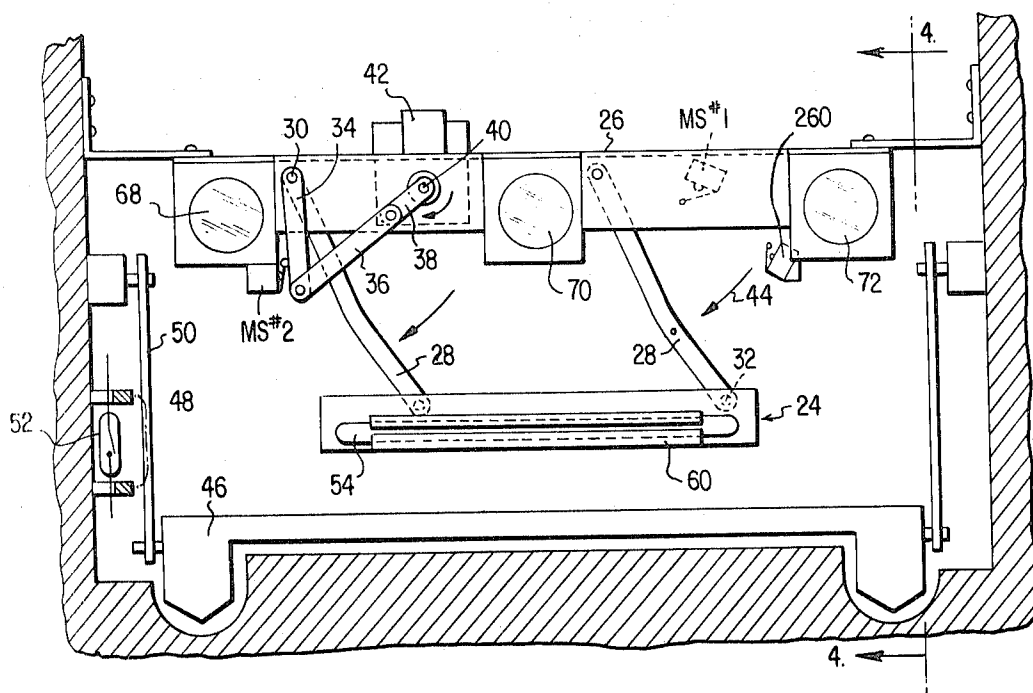


FIG. 3

FIG. 4

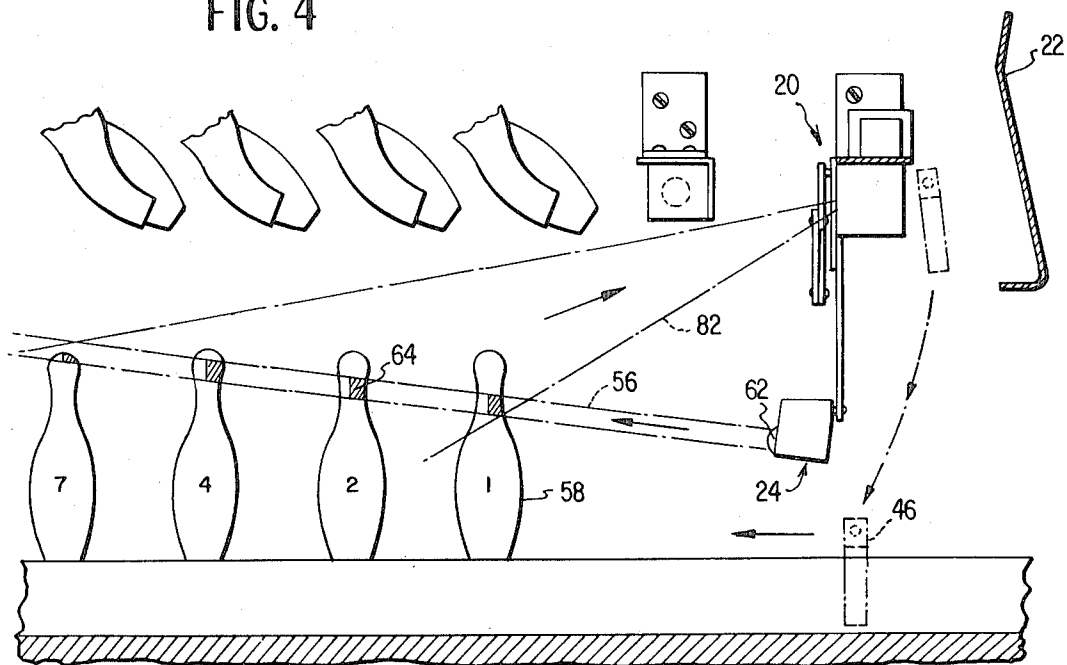
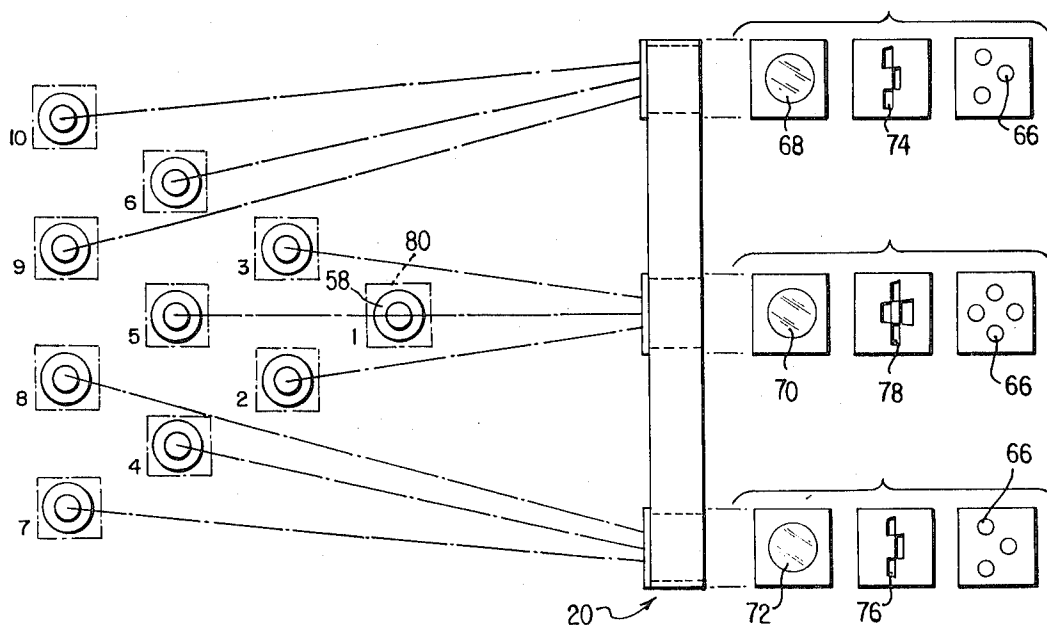


FIG. 5

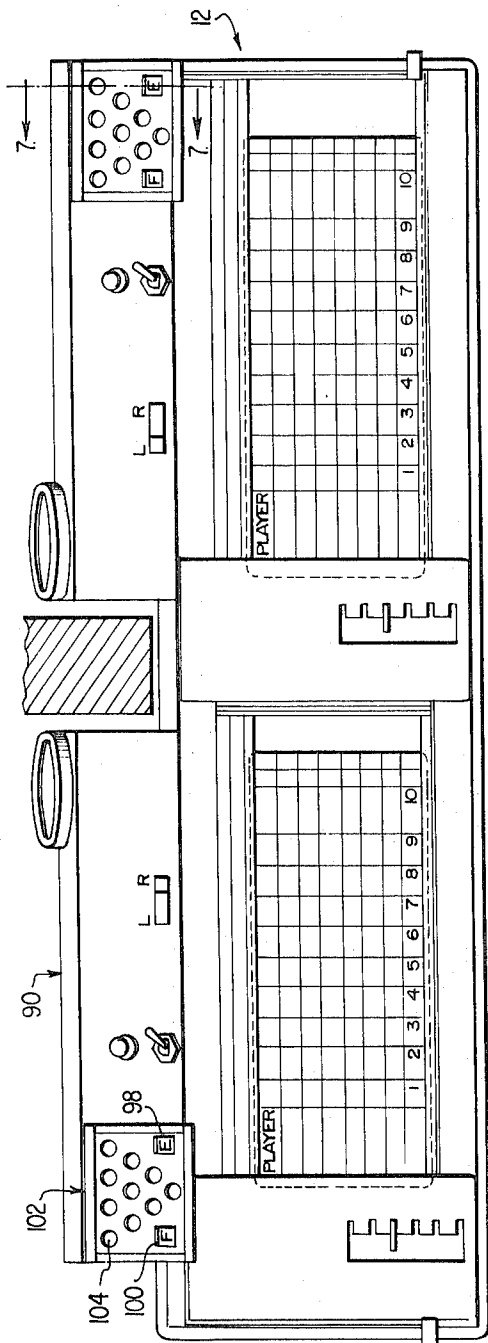


FIG. 6

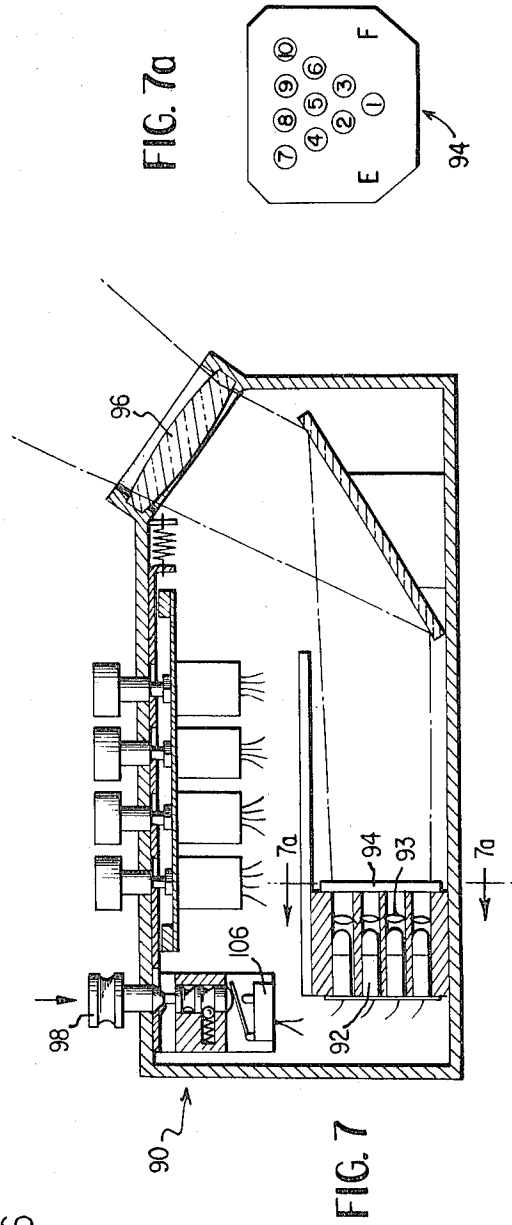


FIG. 7

FIG. 7a

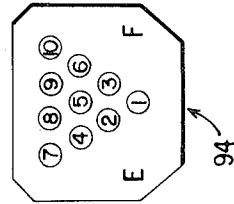


FIG. 8

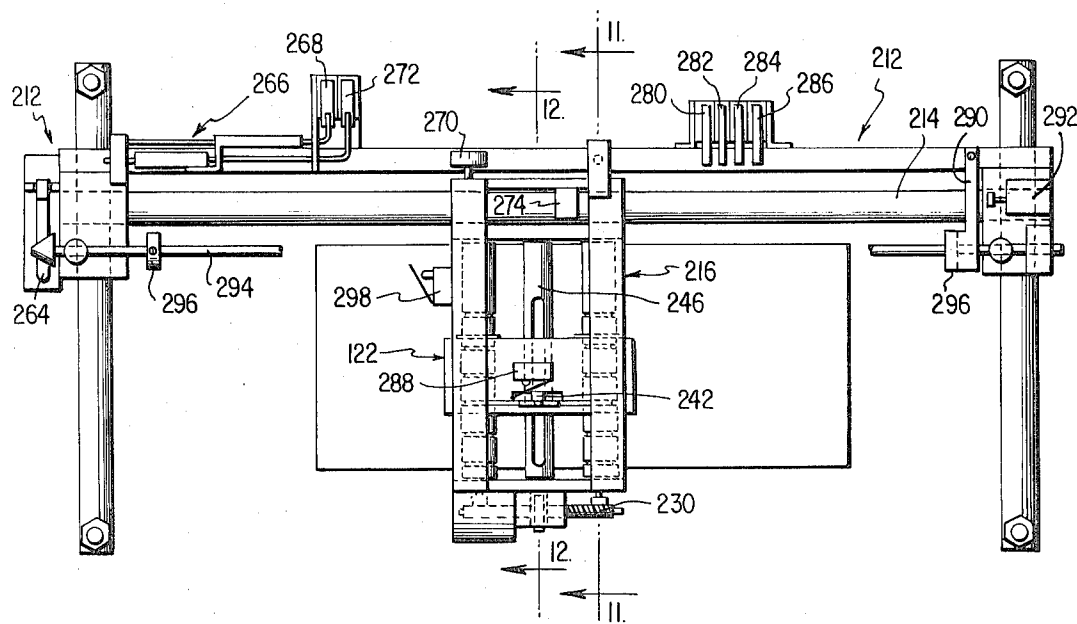


FIG. 9

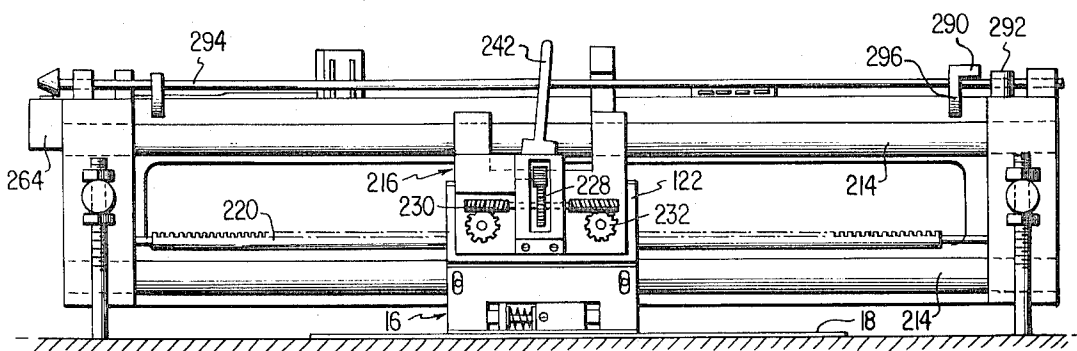
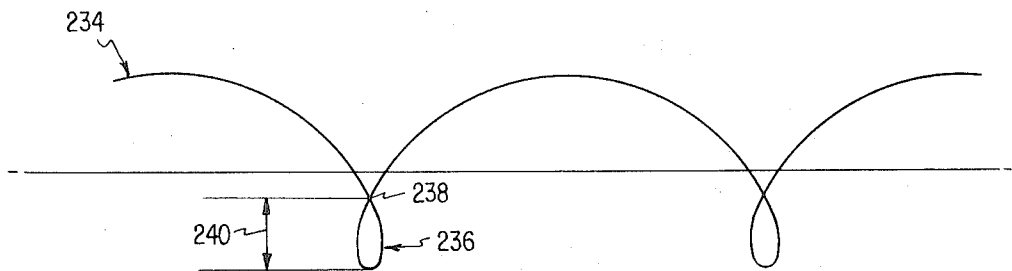


FIG. 10

FIG. 11

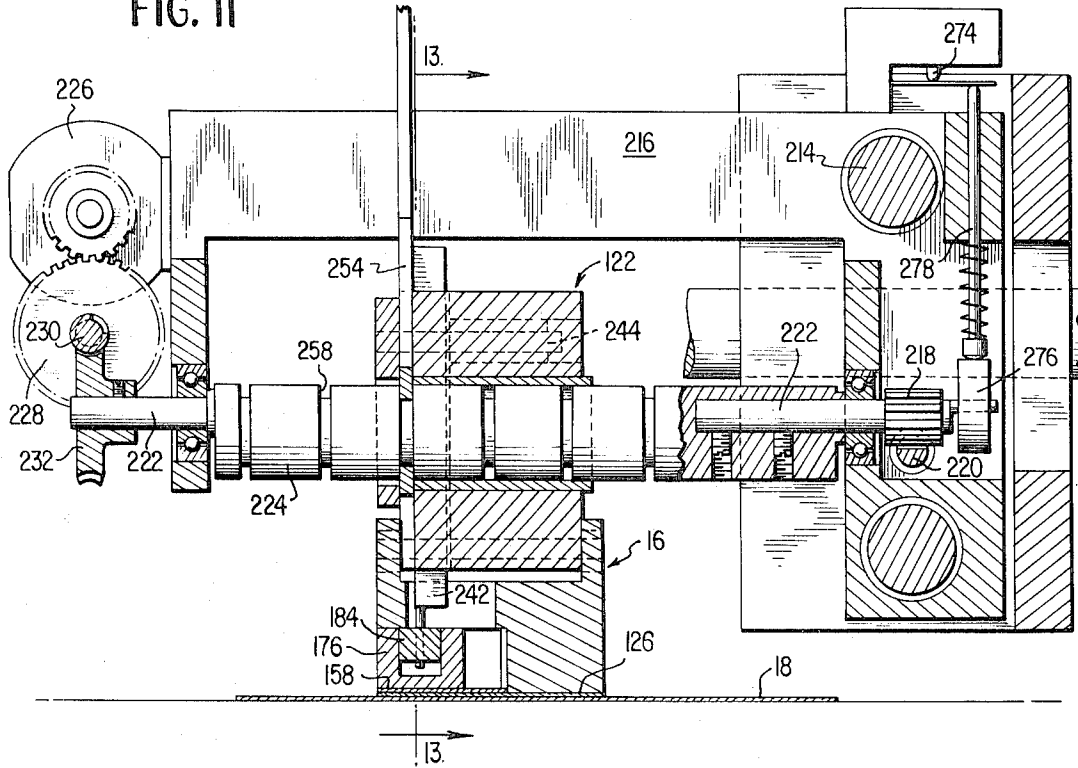
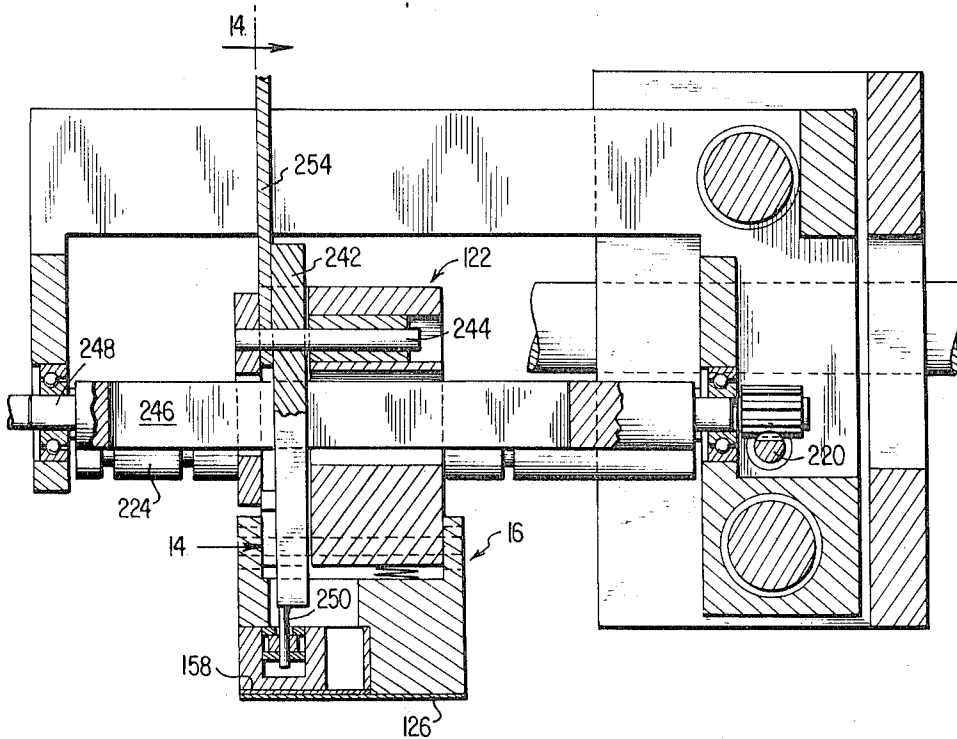
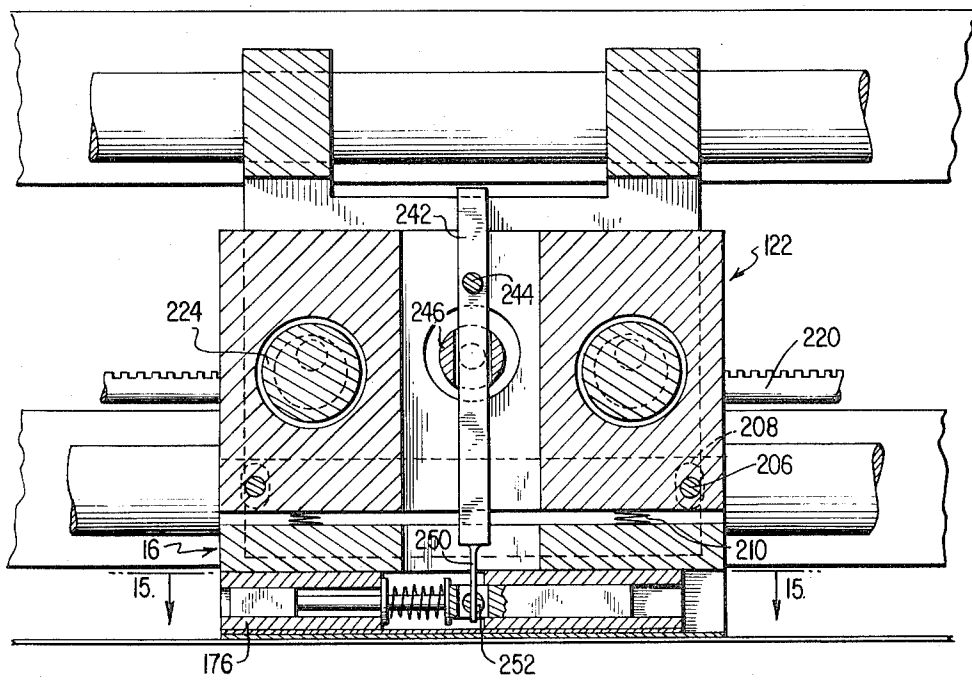
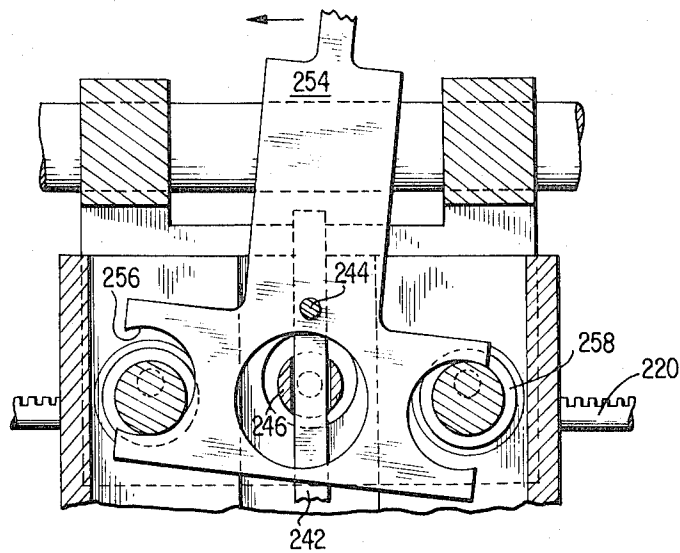


FIG. 12

FIG. 13



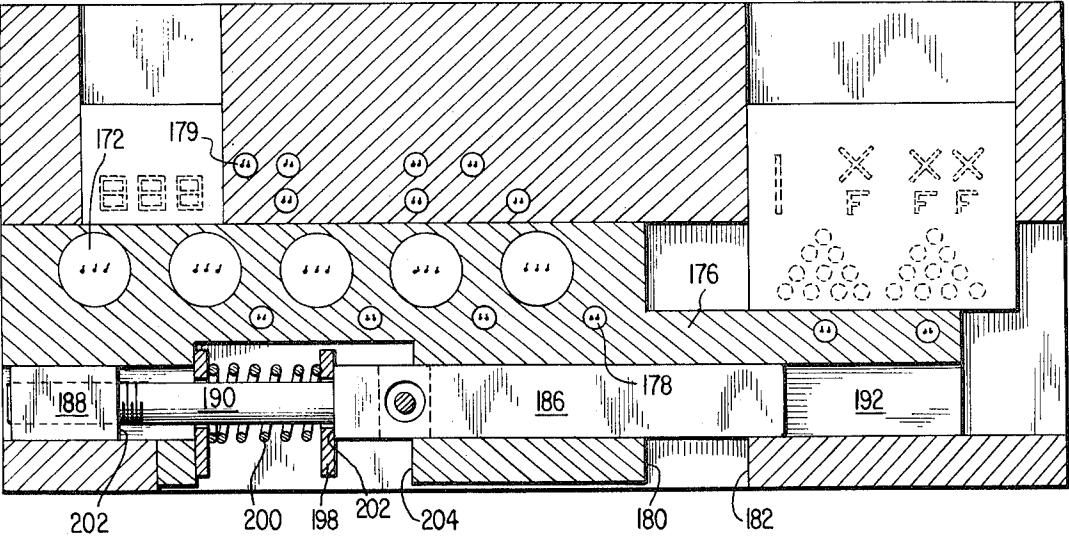


FIG. 15

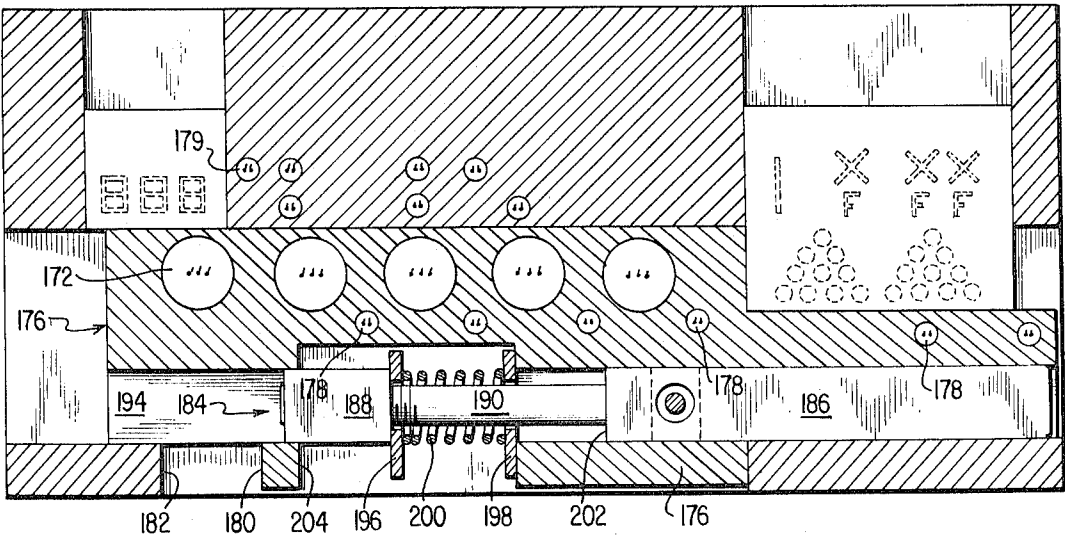


FIG. 16

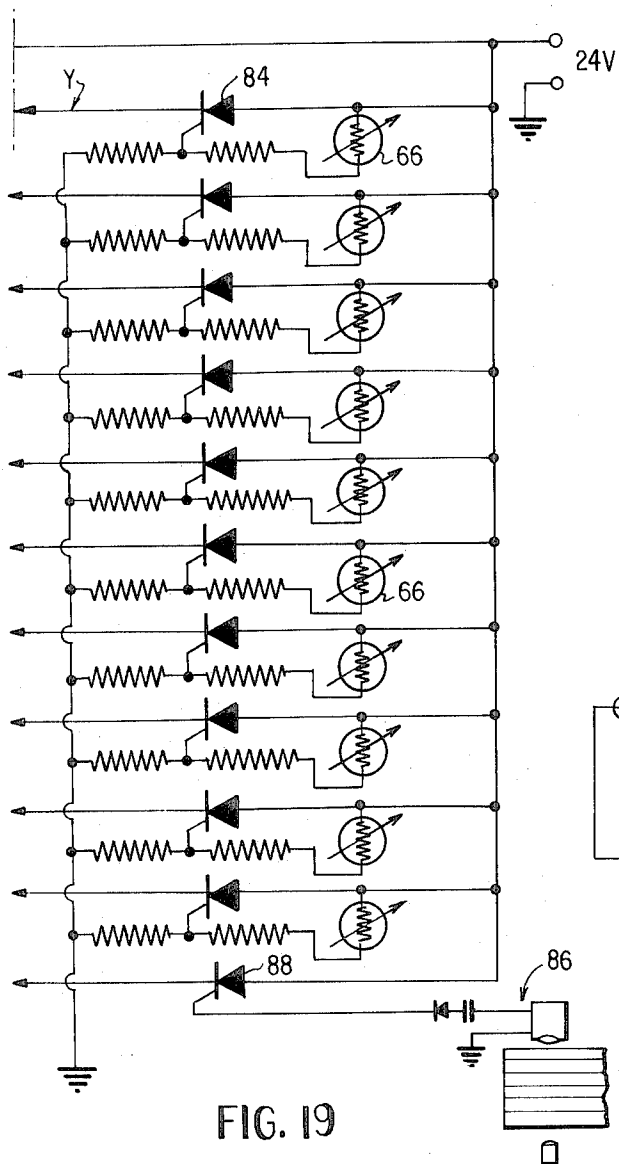
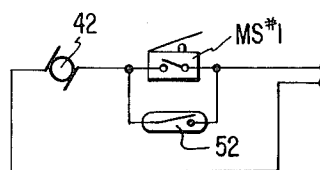
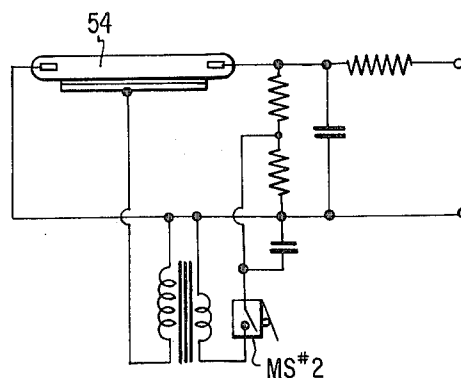
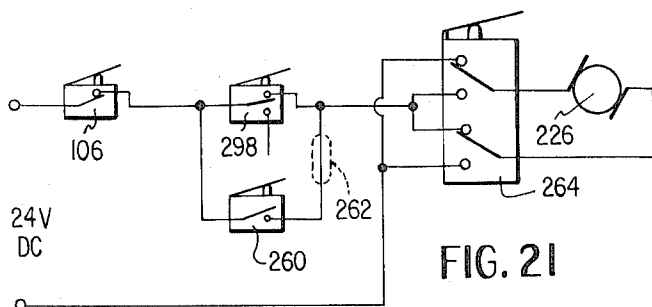


FIG. 17

FIG. 18



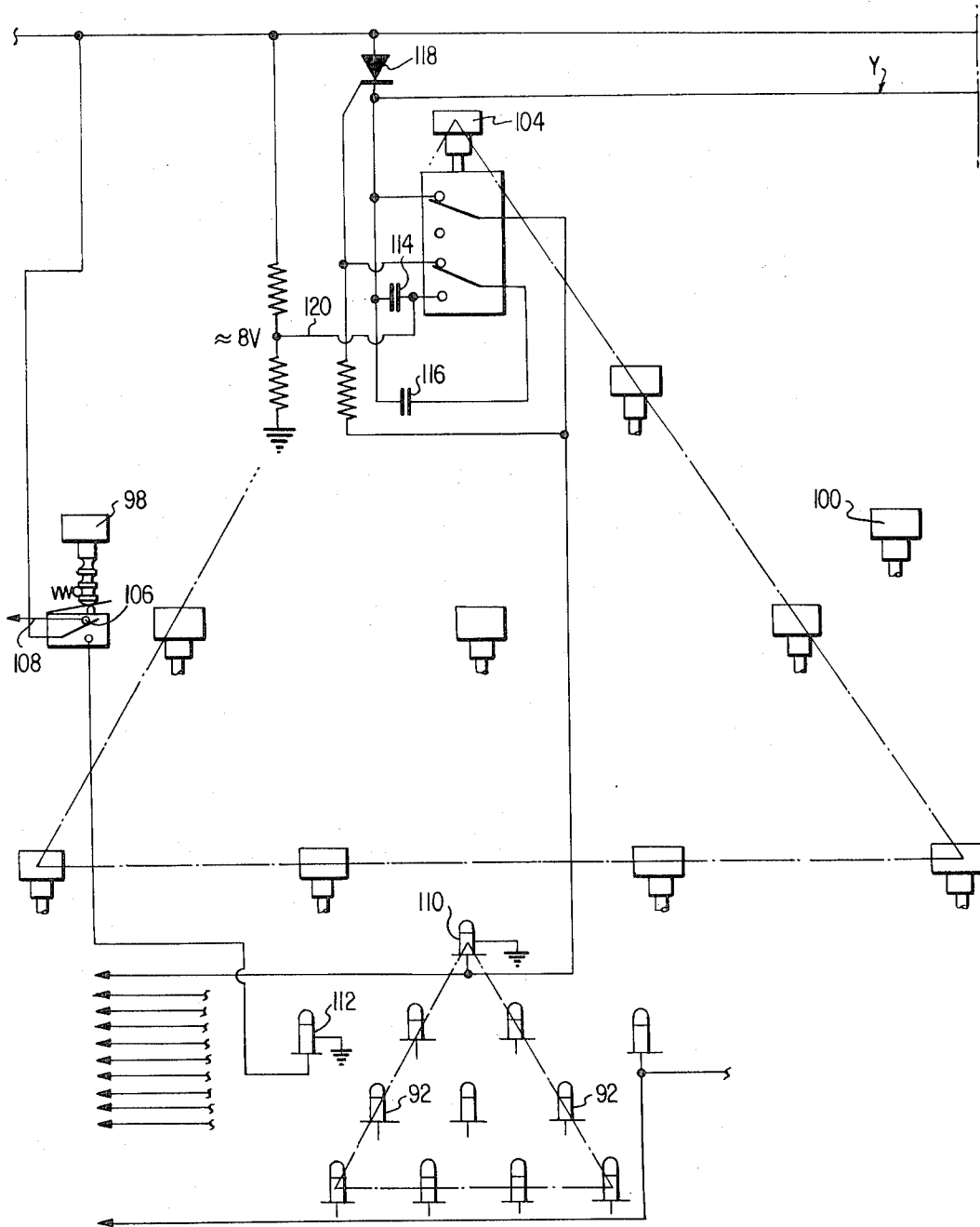


FIG. 20

FIG. 22

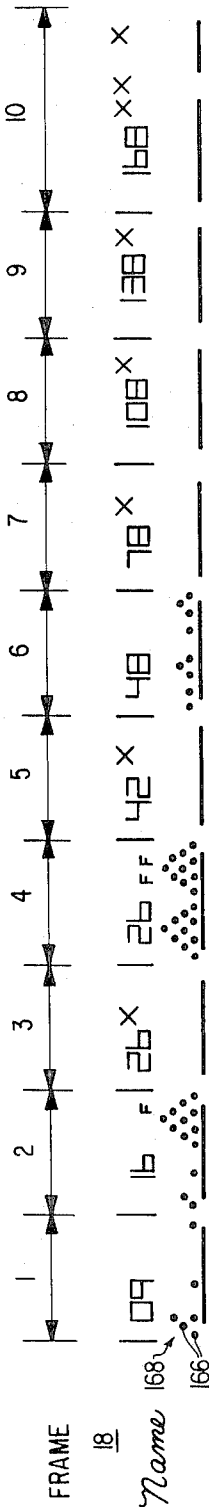
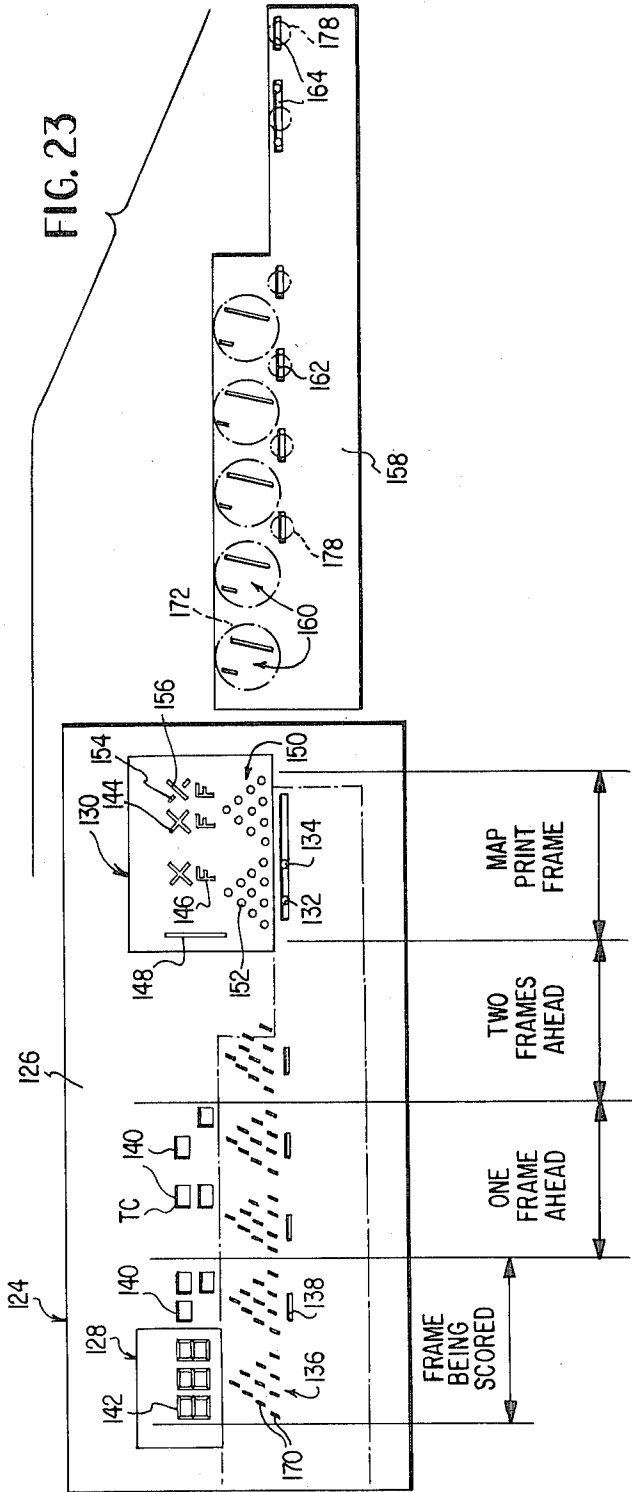


FIG. 24

SEE FIG. 25

—	SWITCH OPEN
—	SWITCH CLOSED
—	INPUT EXISTS
—	INPUT DOES NOT EXIST
—	NO CONSEQUENCE

FRAME	9TH FRAME		10TH FRAME		X2	X1	X2	X1	TA	TA	TC	SB	FB	FB	FC	MA	MB _{IS}	MA _{IS+1}	MB _{IS+1}	MB _{IS+2}	PIN SPOTS
	SW 284	SW 286	SW 284	SW 286																	
1	/	/	●	X	X	X	X	X	○	X	*	○	○	X	X		●				1
2	/	/	●	X	X	X	X	X	○	X	*	○	●	X	X	●					3
3	/	/	●	X	X	X	X	X	●	○	*	X	X	X	X	●		●			10
4	/	/	●	X	X	X	X	X	○	X	*	○	●	X	X	●					10
5	/	/	●	X	X	X	X	X	●	○	*	X	X	X	X			●			4
6	/	/	●	X	X	X	X	X	○	X	*	○	○	X	X		●				4
7	/	/	●	X	X	X	X	X	●	○	*	X	X	X	X				●		0
8	/	/	●	X	X	X	X	X	●	○	*	X	X	X	X				●		0
9	—	/	●	X	X	X	X	X	●	○	*	X	X	X	X			●			0
10	/	—	●	X	X	X	X	X	●	○	*	●	X	X	X	●					0
9A	—	/	●	X	X	X	X	X	○	X	*	●	X	X	X						2
10A	/	—	●	X	X	X	X	X	○	X	*	●	X	X	X	●					0
9B	—	/	●	X	X	X	X	X	○	X	*	○	○	X	X		●				1
10B	/	—	●	X	X	X	X	X	○	X	*	○	○	X	X		●				1

MECH. SWITCHES

↓

SYMBOL PHOTOSENSORS

↓

SLIT & PHOTOSENSOR

↓

READ

↓

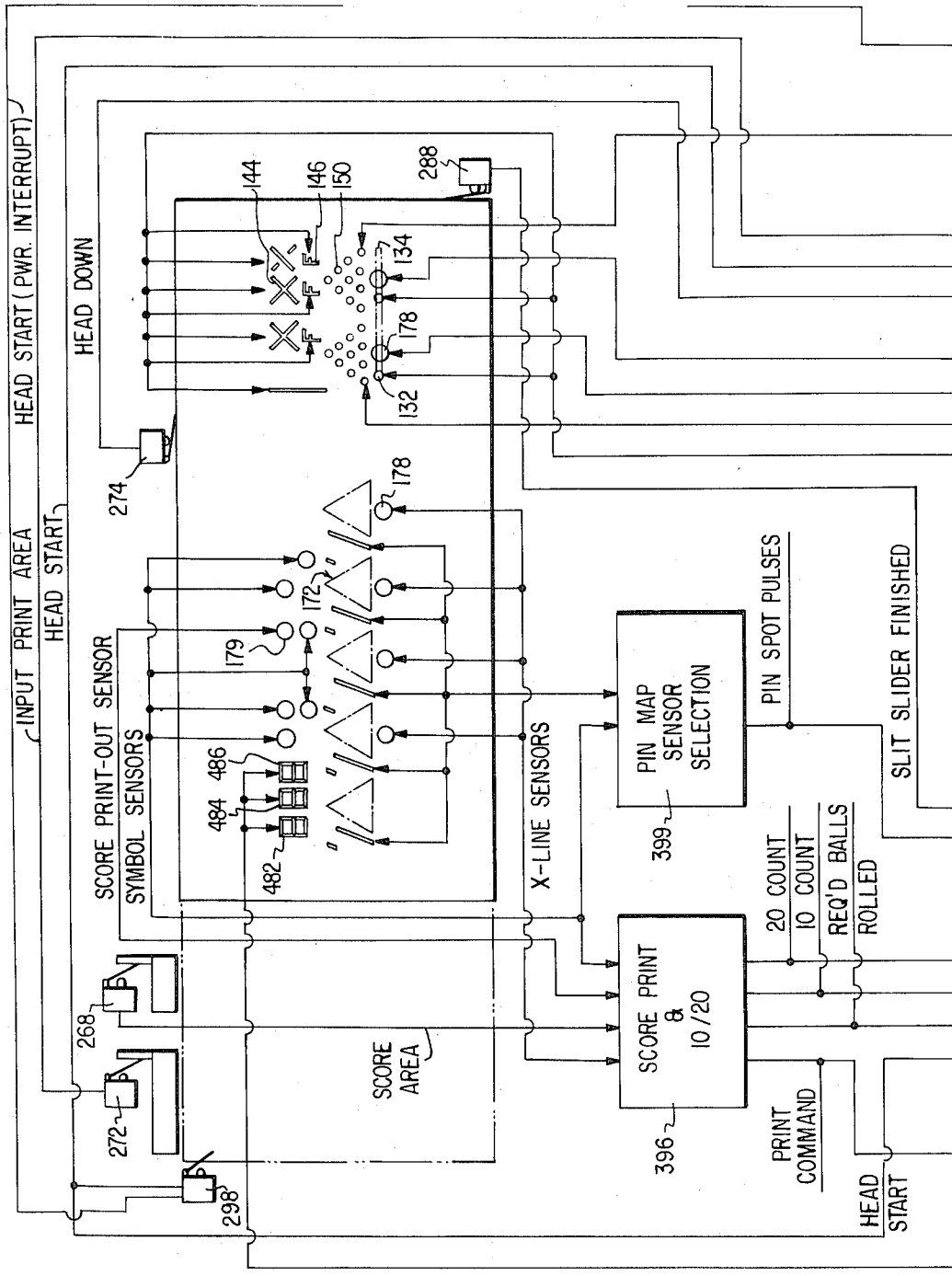
USED TO DETECT DIGIT PRINT-OUT IN 1 FRAME AHEAD

FIG. 25

SEE FIG. 24

PIN	MAP	SCORE	PINS	+10	+20	FRAME	TOTAL
SEL.	READY	DOWN				SCORE	SCORE
GATE	GATE						
NG 398	NG 588	9				9	9
NG 554	NG 588	7				7	16
NG 562	NG 498	0	●			10	26
NG 554	NG 588	0				0	26
NG 572	NG 498	6	●			16	42
NG 398	NG 588	6				6	48
NG 590	NG 578	10		●		30	78
NG 590	NG 578	10		●		30	108
NG 598	NG 596	10		●		30	138
NG 604	NG 542	10		●		30	168
							108
NG 612	NG 494	8	●			18	126
NG 612	NG 494	10	●			20	146
							108
NG 398	NG 588	9				9	117
NG 398	NG 588	9				9	126

ELECTRONICS FUNCTIONS



SEE FIG. 27

FIG. 26

SEE FIG. 26

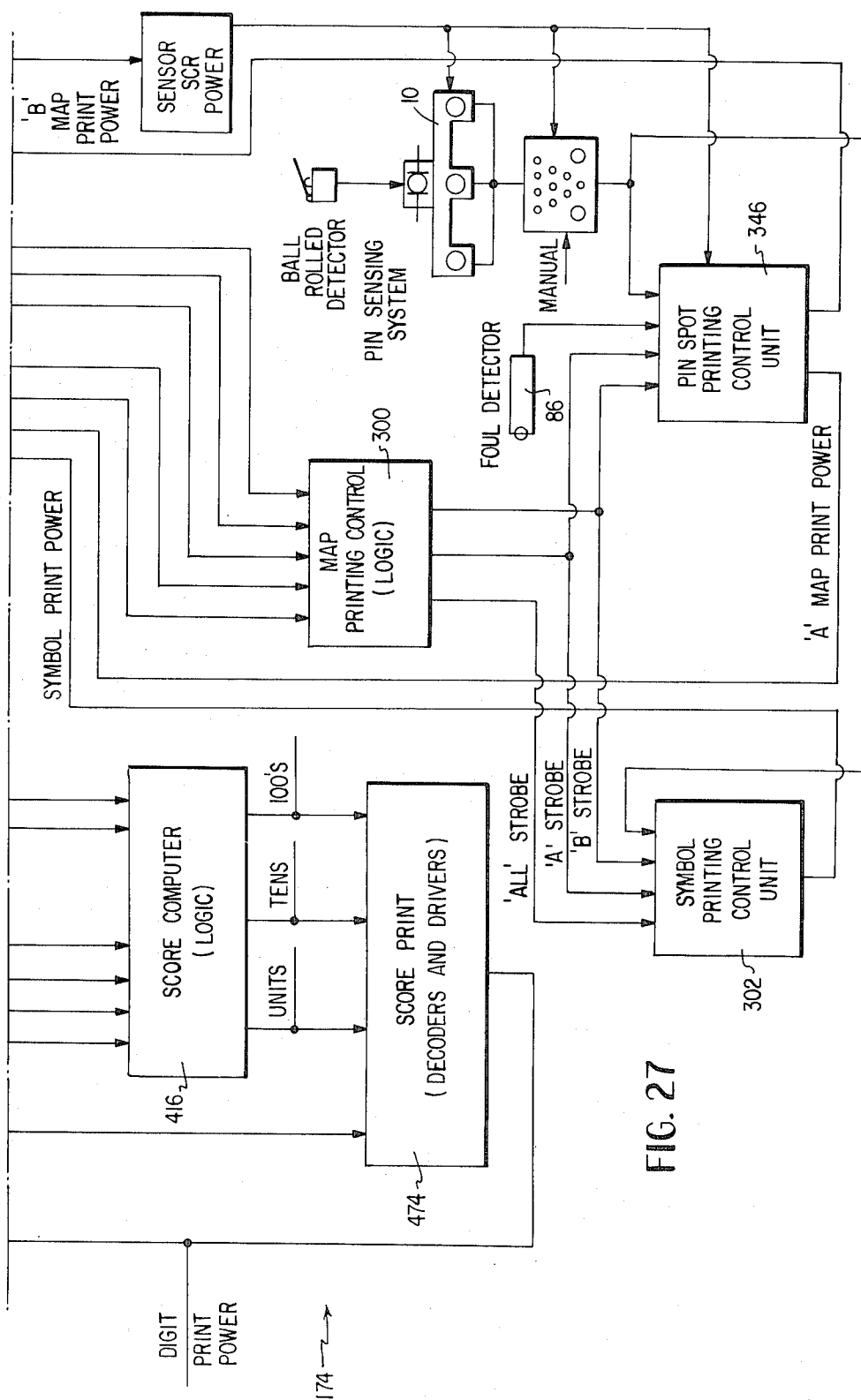


FIG. 27

FIG. 28A

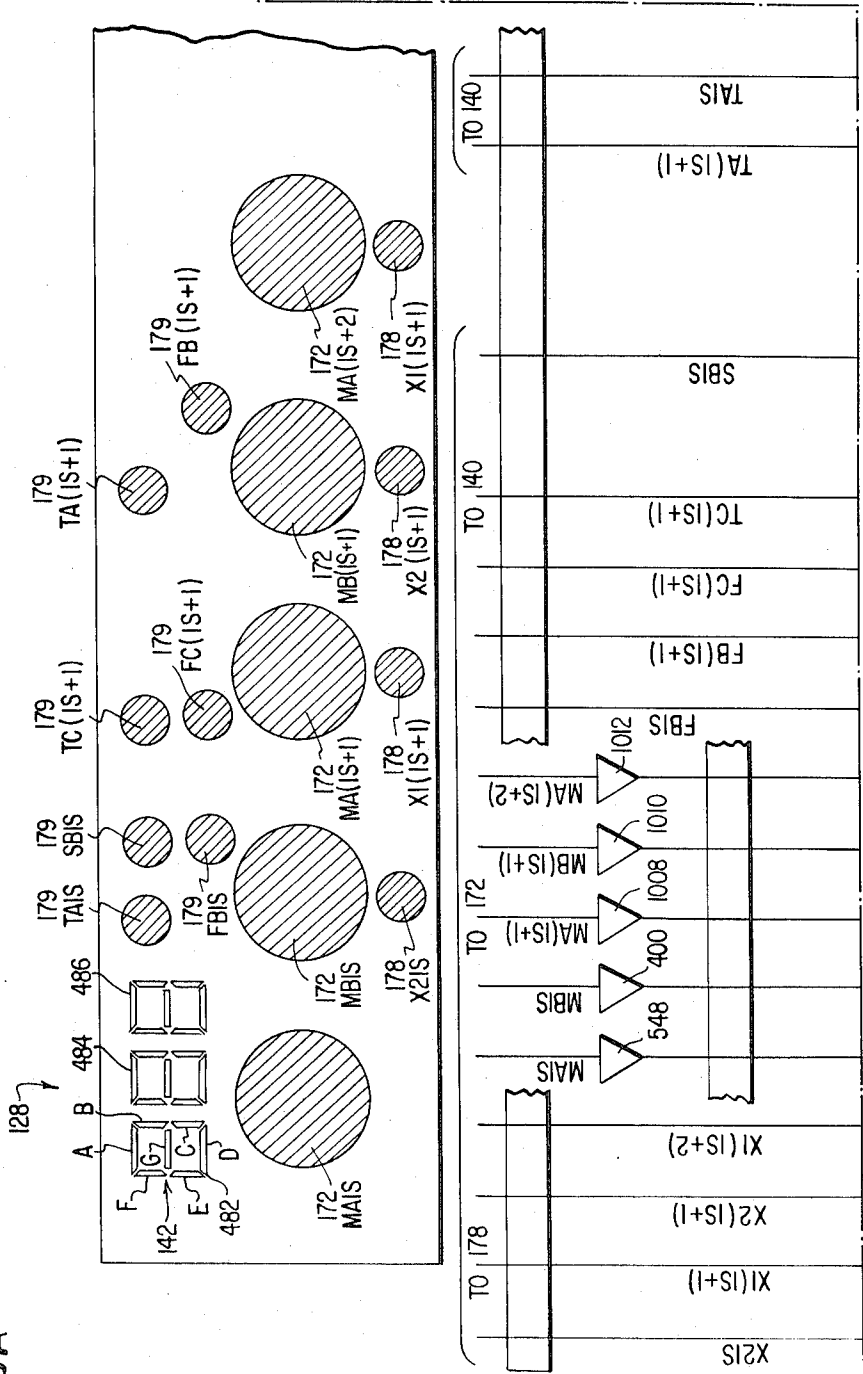
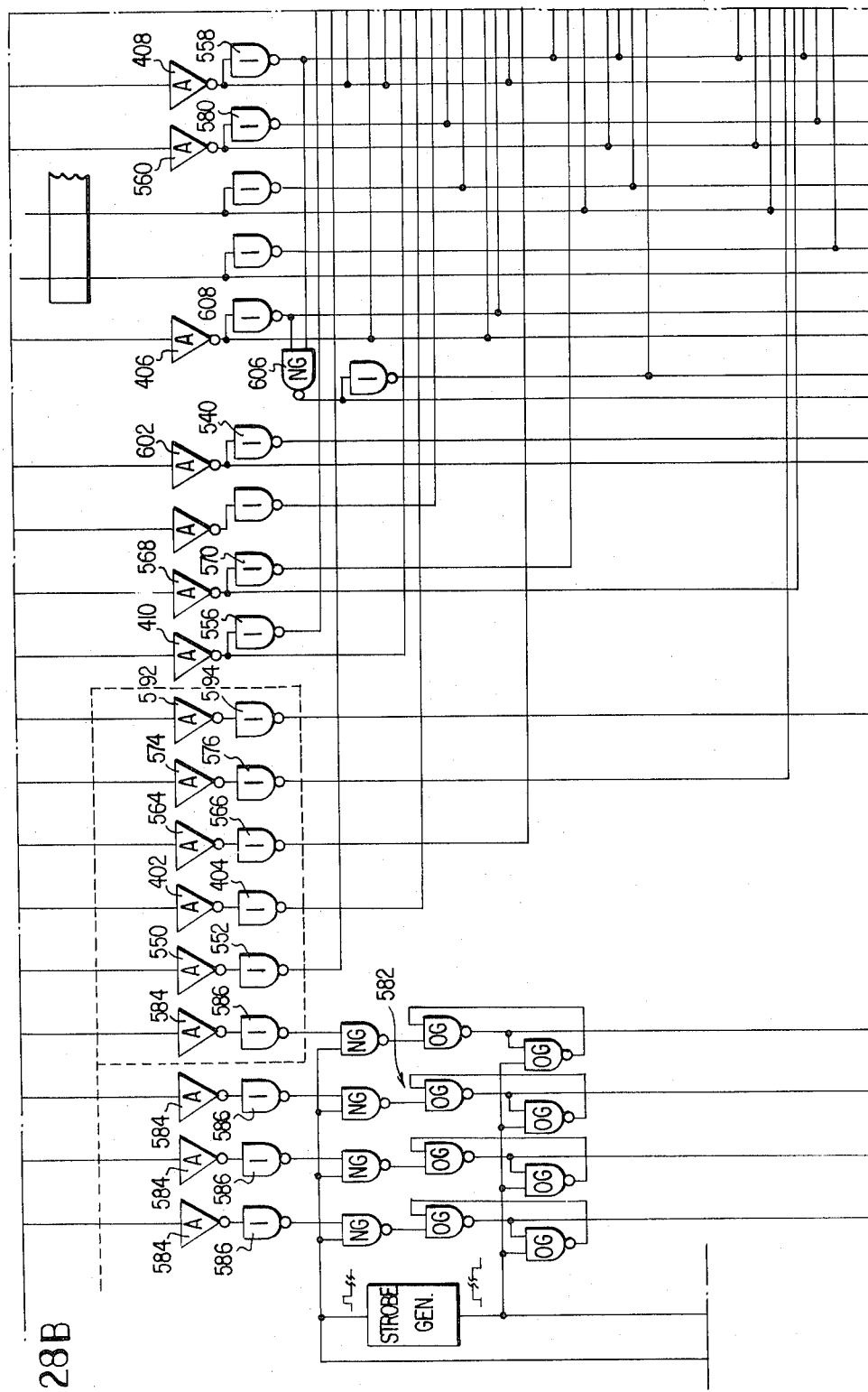


FIG. 28B



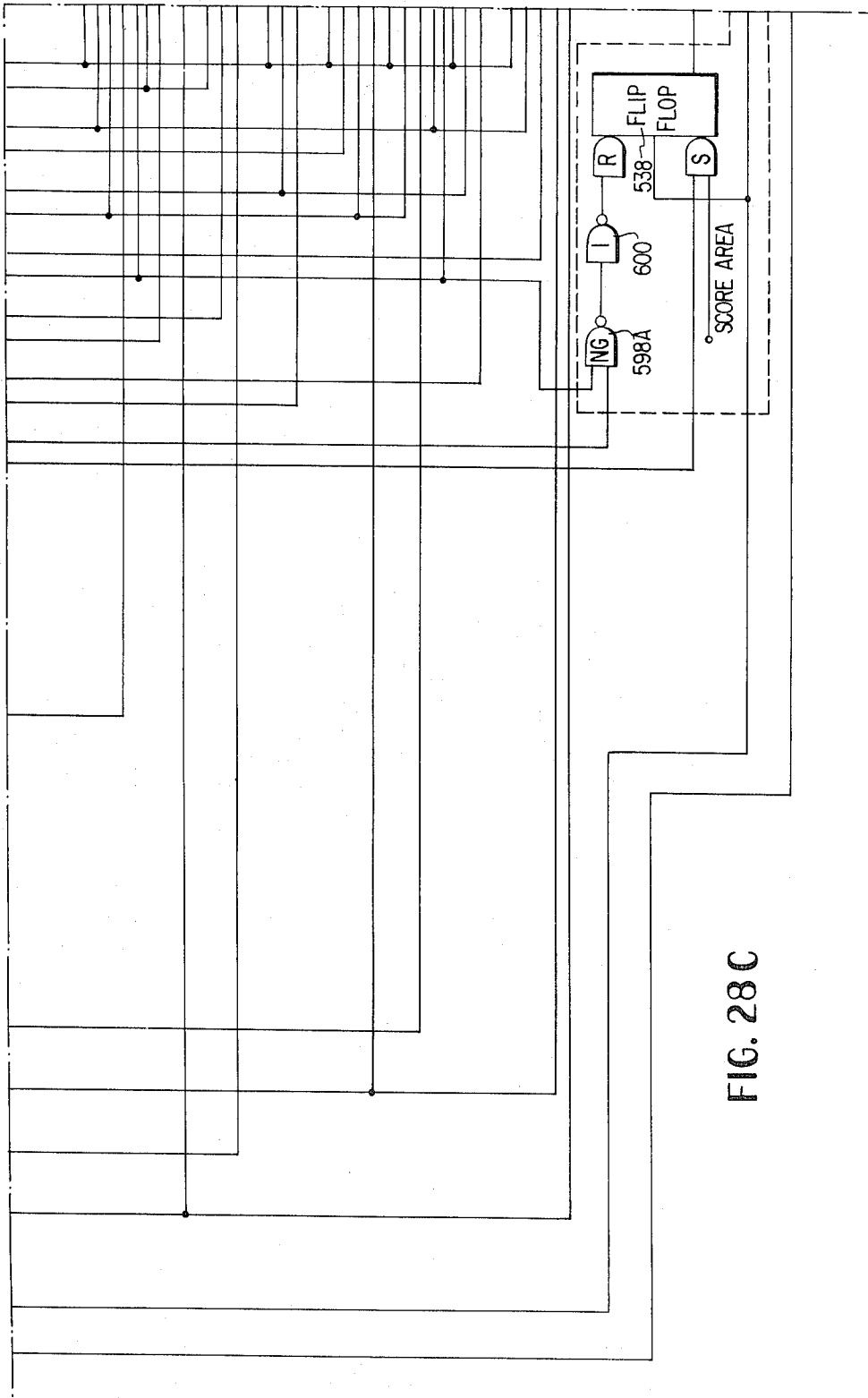
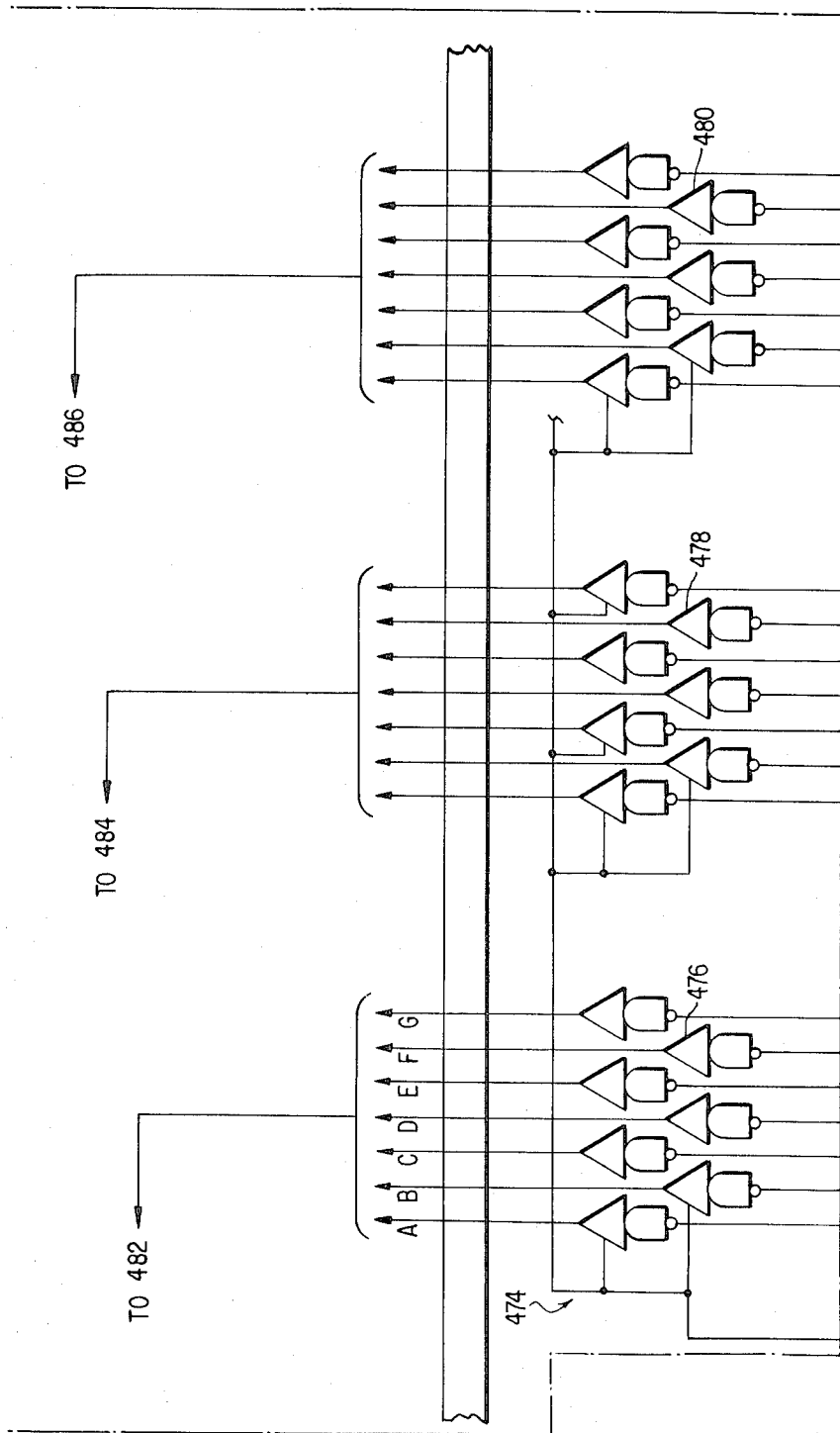


FIG. 28C

FIG. 28 D



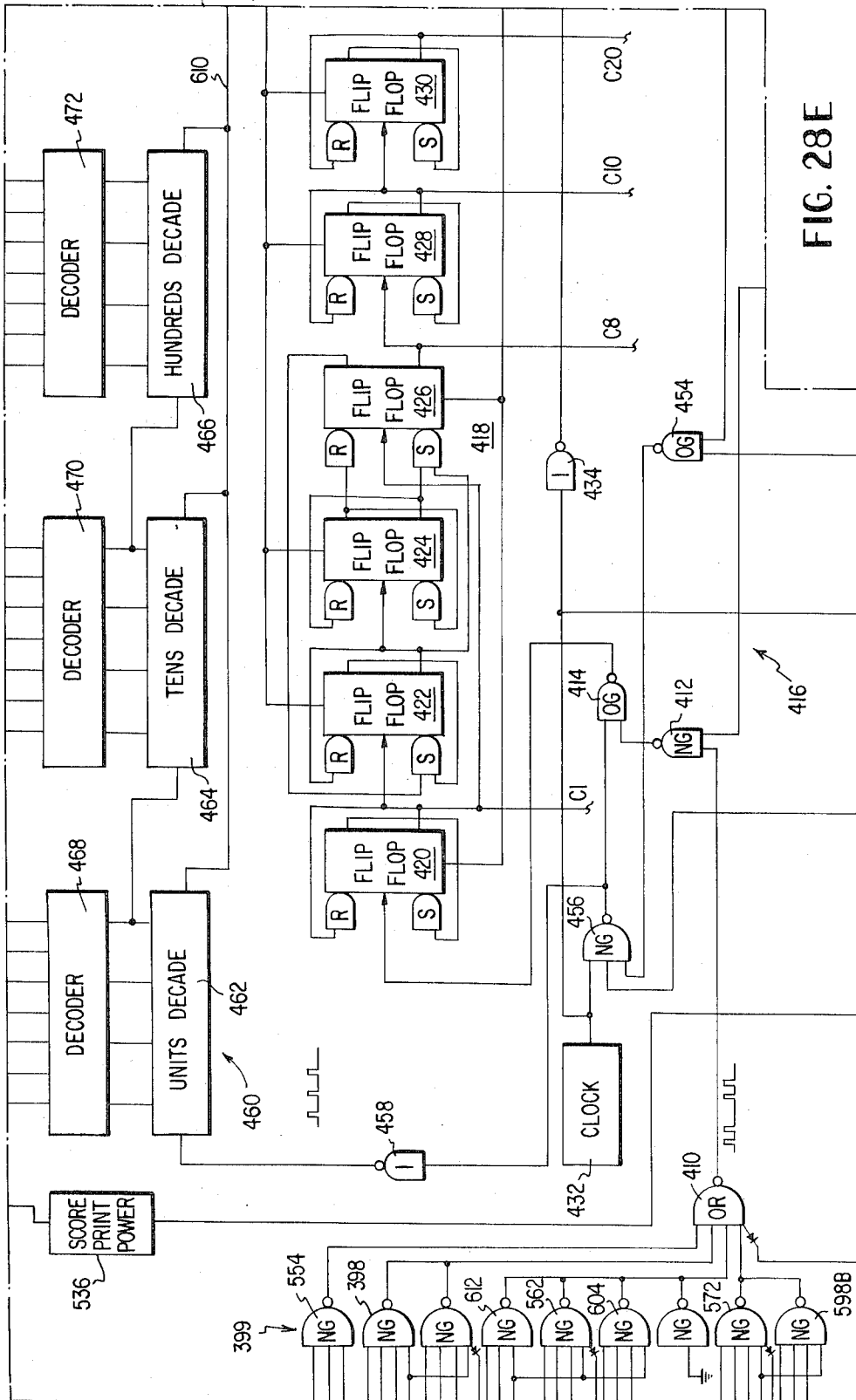
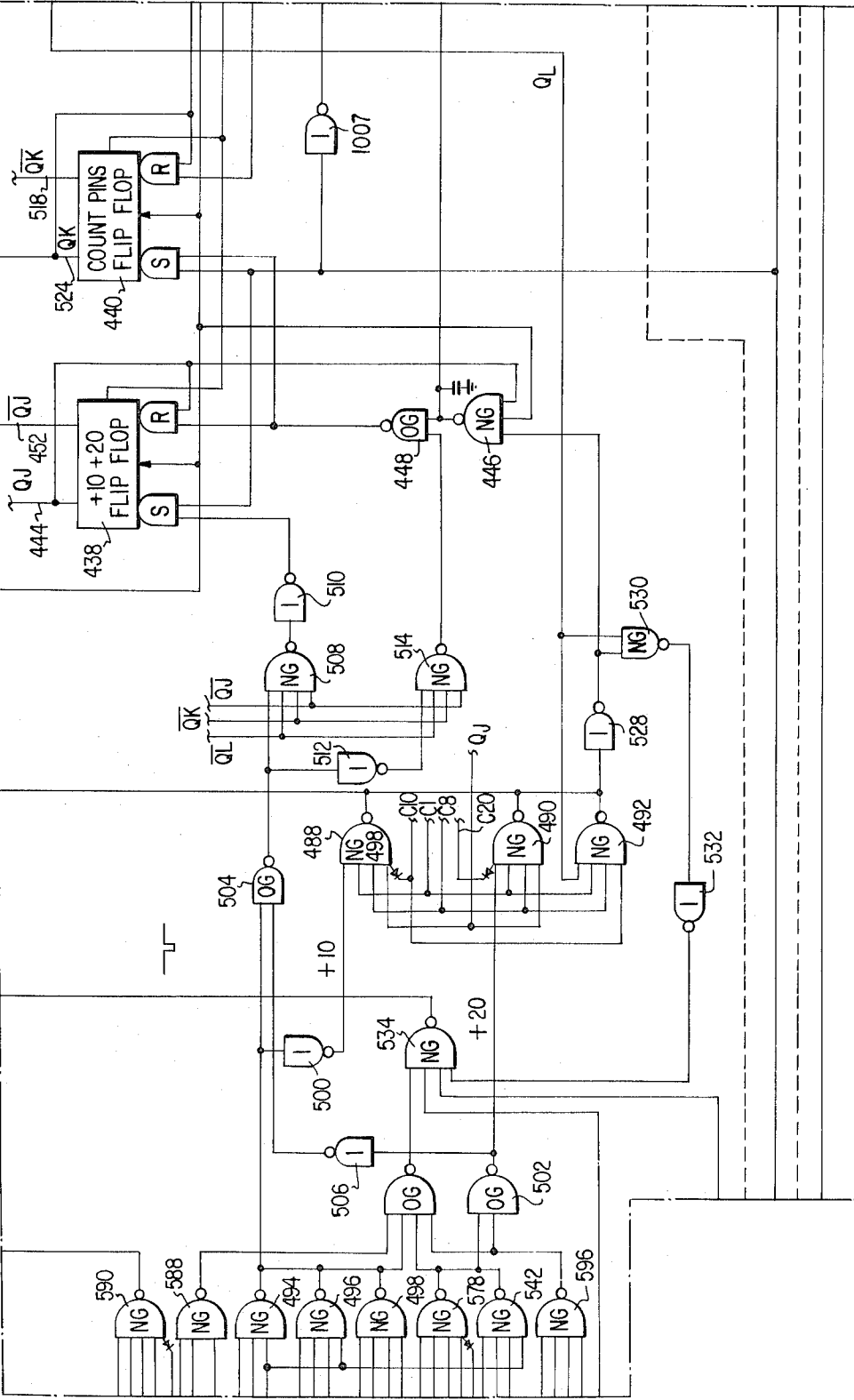


FIG. 28E

FIG. 28F



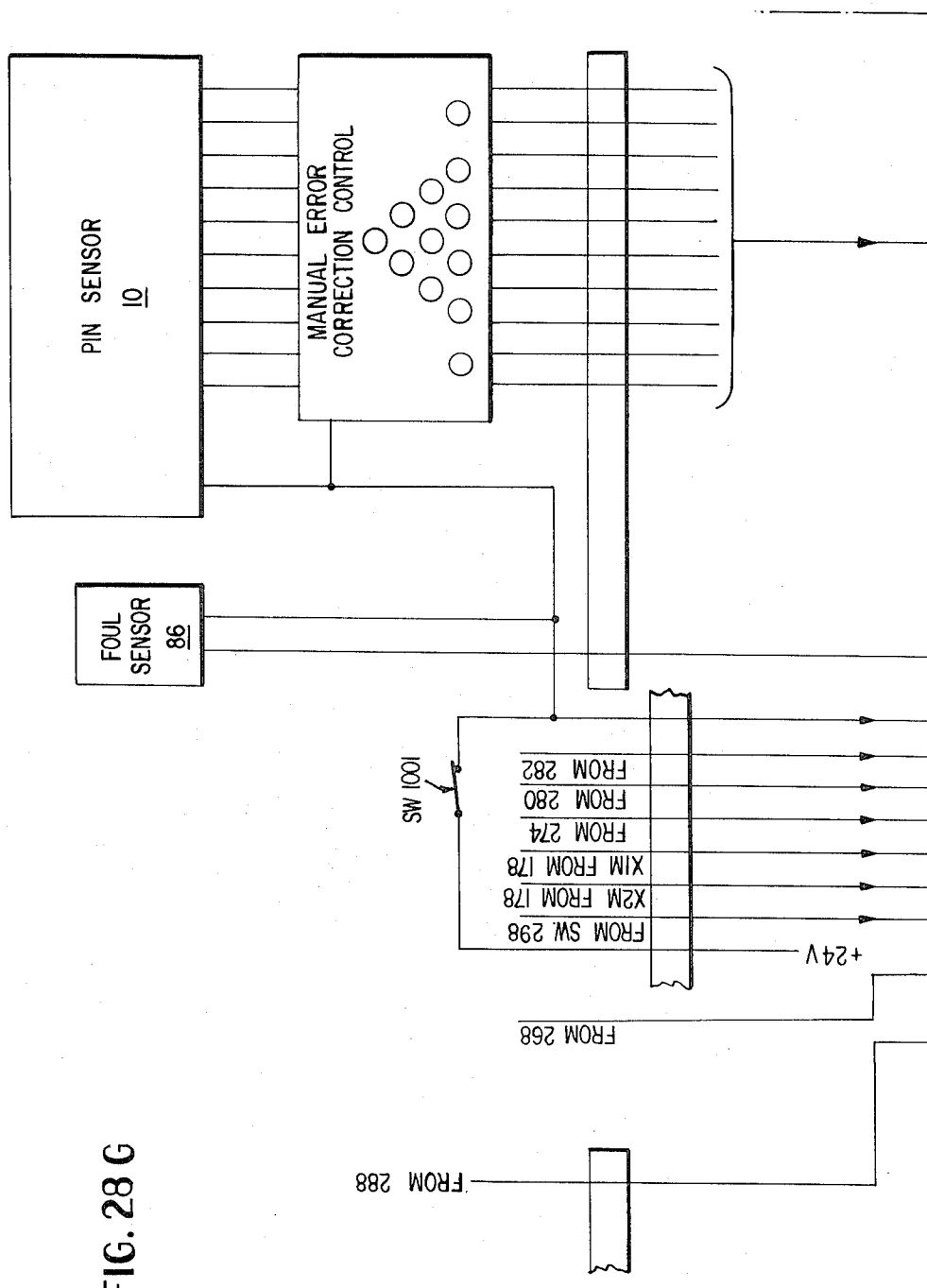


FIG. 28 G

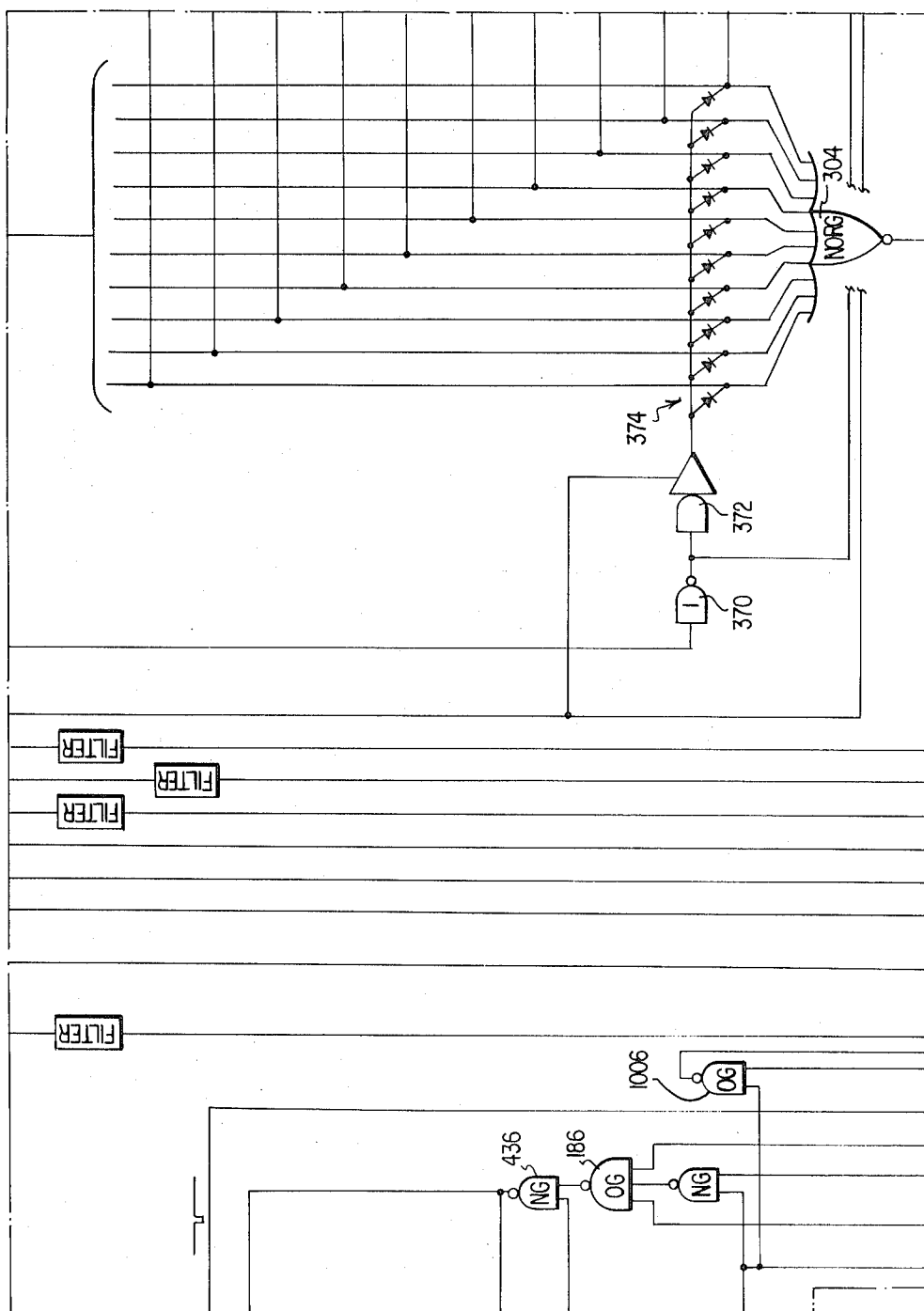


FIG. 28H

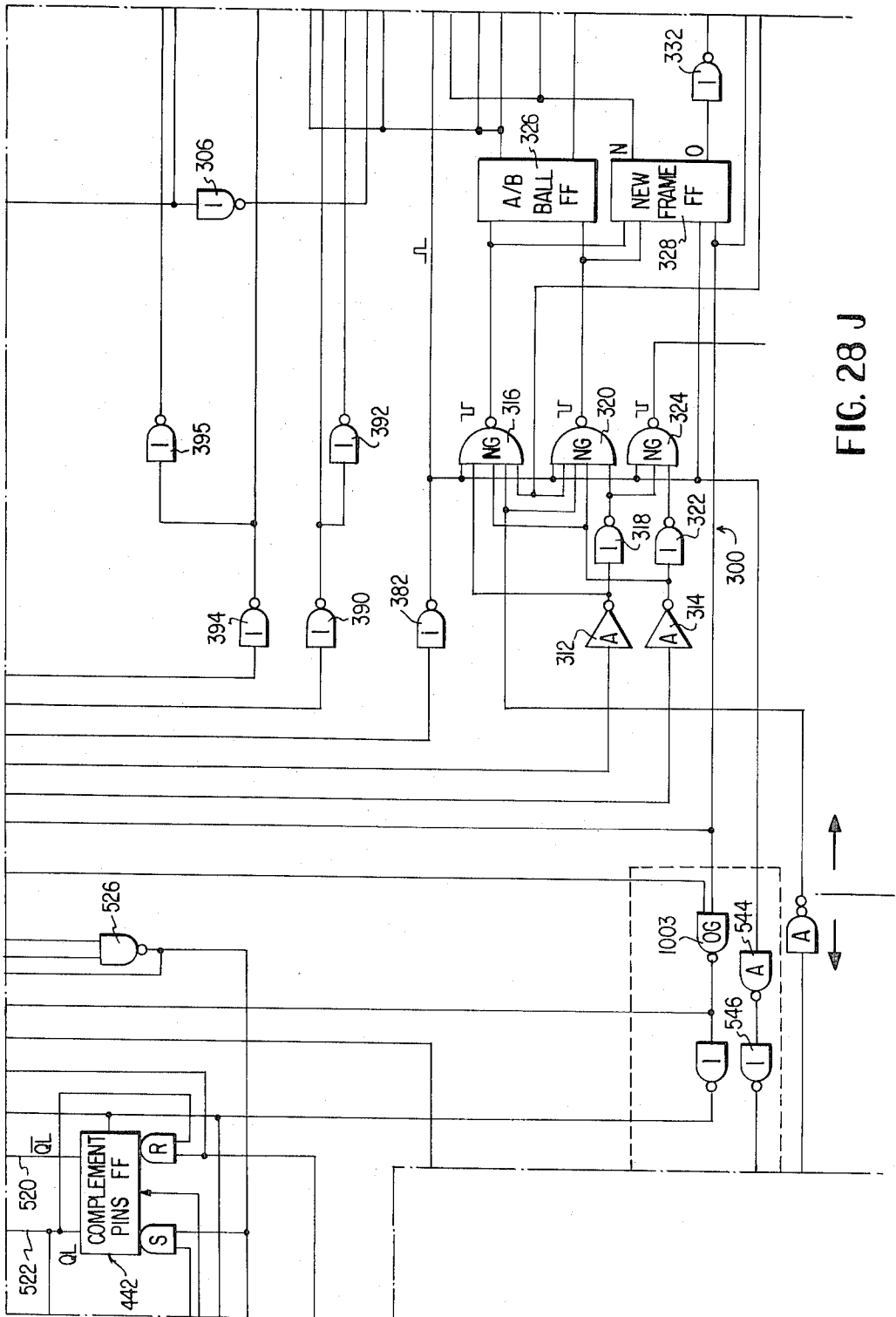
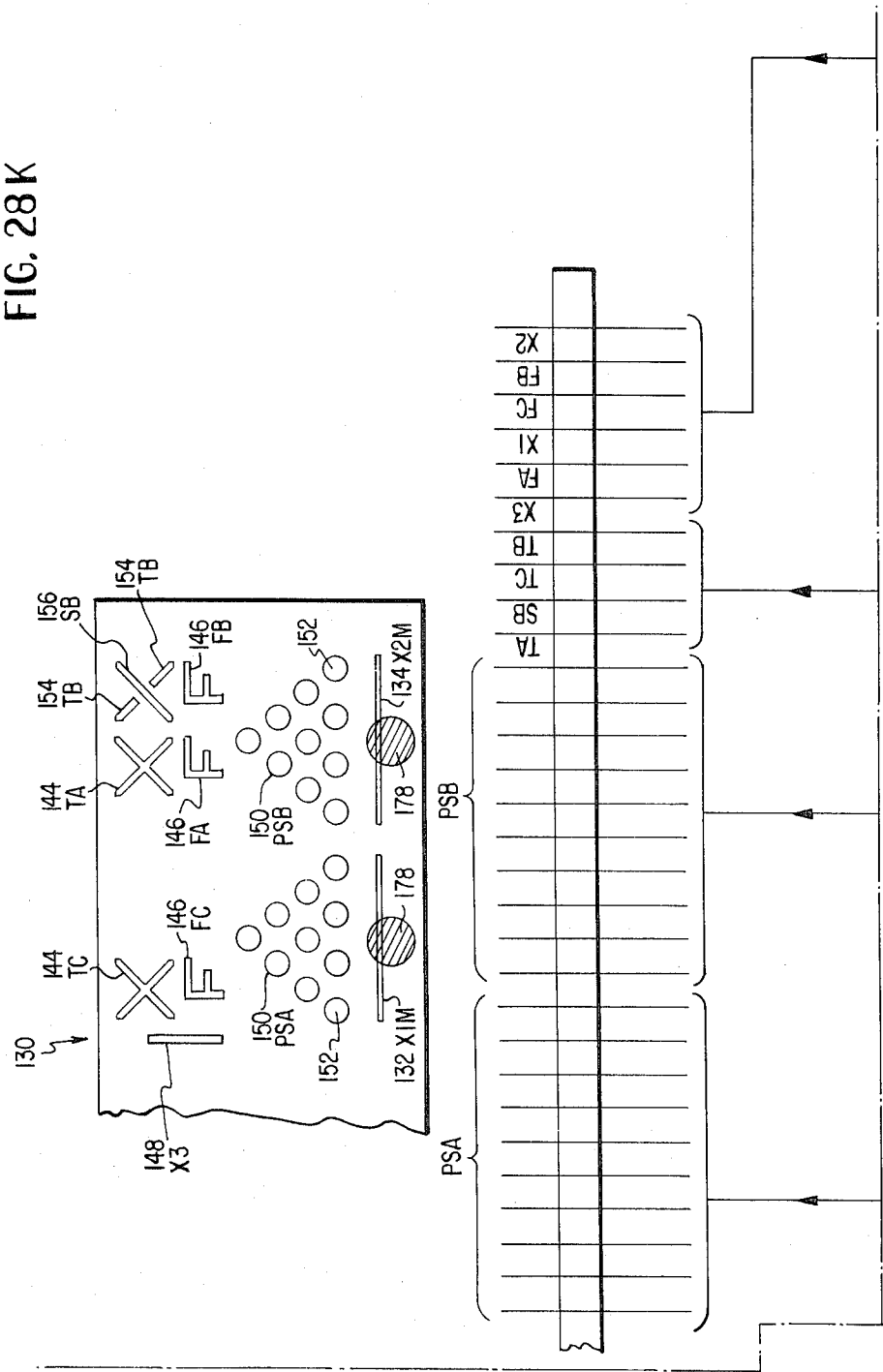


FIG. 28 J

FIG. 28K



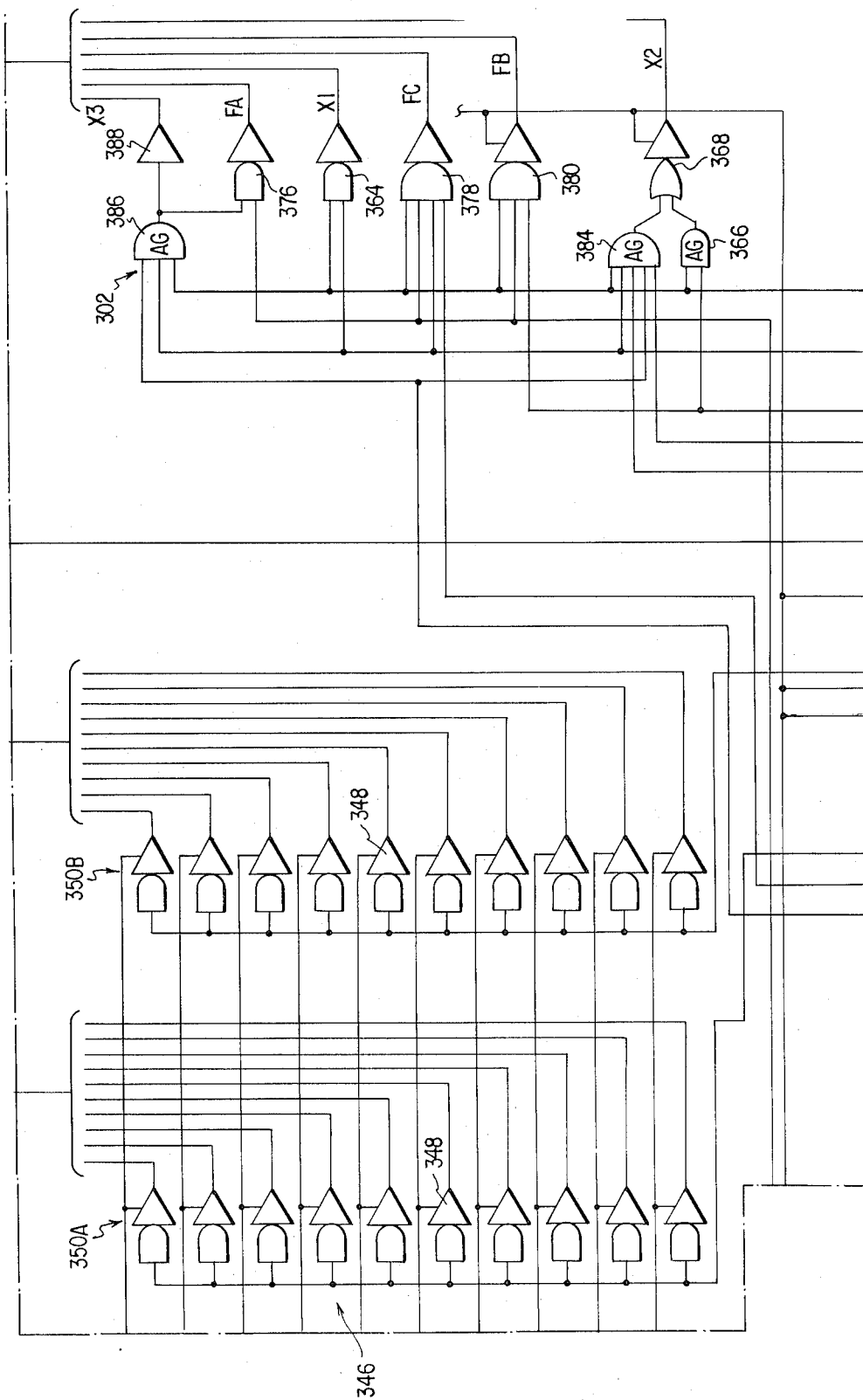


FIG. 28L

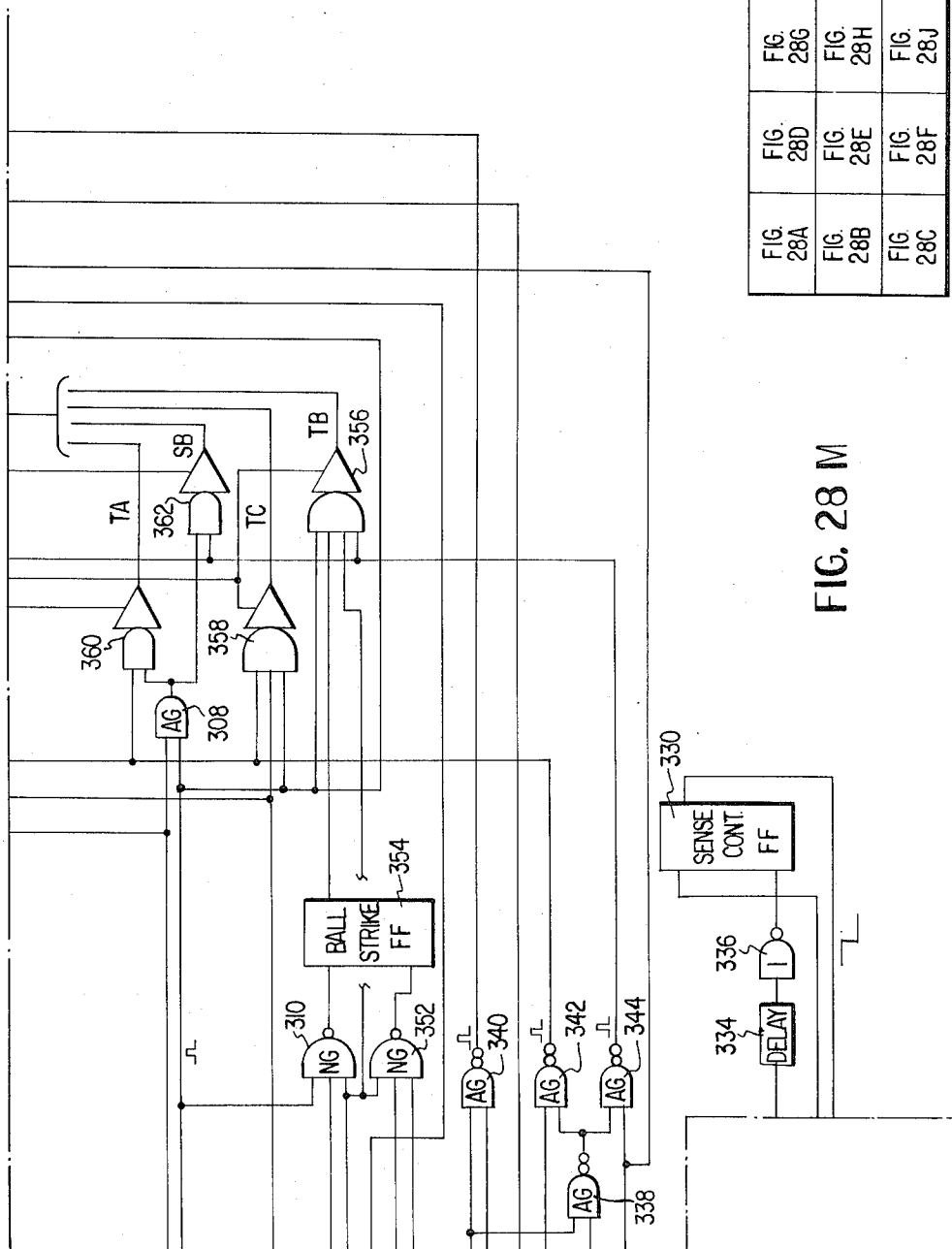


FIG. 28 M

FIG. 28A	FIG. 28D	FIG. 28G	FIG. 28K
FIG. 28B	FIG. 28E	FIG. 28H	FIG. 28L
FIG. 28C	FIG. 28F	FIG. 28J	FIG. 28M

PIN SENSING SYSTEM

This is a division of application Ser. No. 44,733 filed June 9, 1970, and now U.S. Pat. No. 3,705,722.

BACKGROUND OF THE INVENTION

The development of an automatic bowling scorekeeper which will successfully cope with the complex functional requirements which are necessarily imposed by the nature of the game has defied numerous costly attempts to produce a commercially acceptable system.

The greatest single deterrent to widespread commercial acceptance of the previously developed automatic scorekeepers has been the purchase price. A very significant factor in a cost analysis break-down is the logic and computer section and, particularly, the multiple memory banks associated therewith; a separate memory bank being required for each of the maximum number of players who may bowl together at a given time. Thus, in a typical arrangement, six memory banks will be required for each computer section associated with a particular bowling lane which represents a substantial factor in the purchase price.

Another significant cost factor in those commercially available scorekeepers employing optical sensing systems of the type disclosed in U. S. Pat. No. 3,140,872 is the necessary duplication of much of the control circuitry. Exemplary of such duplication is the necessary utilization of multiple flash lamps (4) and their associated control circuits plus the requirement for a time delay circuit in the output from each photosensitive element.

Installation costs, in addition to that of the scorekeepers themselves, represent a further contributory factor in the low commercial acceptance of these units since it is normally necessary to replace the conventional manual scoring console with one especially adapted for automatic scoring. Removal of the conventional console usually represents a dead loss of equipment.

In addition to the cost factor, a major consideration which must be borne in mind is the fact that there is little advantage, per se, to the owner of a bowling alley in the installation of automatic scorekeepers apart from the attraction of additional customers. Stated differently, the average bowler must be more than merely satisfied with an automatic scorekeeping system if the same is to justify its substantial expense by the attraction of additional bowlers. Previous scorekeepers have been deficient in this respect primarily in their inability to print-out clearly defined, high contrast symbols at least as readily legible as those that might be scribed by the bowlers themselves. The quality of the symbol print-out from conventional scorekeepers has actually been decreased when projected onto the viewing screen because of the optical characteristics of the symbols and the background on which they are printed.

Thus in the present commercially developed scorekeepers, impact printers, functioning in a manner somewhat similar to typewriters, make an original print-out on a substantially opaque score sheet. The print-out is transferred to an underlying transparent substrate through a wax or carbon coating which is then utilized as the projection negative.

In the case of the wax imprint, the light absorption quality of the wax vis-a-vis that of a glass substrate in a reflected light projection system is relied upon to provide the projected symbol contrast. It is apparent on its face that such differential light absorption qualities cannot provide a high contrast comparable to that obtained by conventional manual scoring with a grease pencil where the symbols are substantially opaque and project with high contrast and reasonably clear definition.

Although it might appear that the transferred coating type of print-out would provide a reasonable contrast, such is not the case as will be apparent to those having attempted to mark through carbon paper onto a transparent substrate such as flexible plastic sheet comparable to that conventionally used in the manual scoring of league bowling. The contrast is very poor and the projected symbols, if legible at all, are fuzzy about their edges.

It will be quite apparent that the lack of a high resolution projected print-out would be entirely unsatisfactory to a bowler if it is not at least as legible as that which would be obtained with manual scoring. In such event, it is entirely reasonable that many bowlers might avoid a particular bowling house employing such scorers.

A frequent source of irritation to bowling participants utilizing existing automatic scoring equipment is the print-out of an erroneous score which may readily occur through no fault of the equipment itself. Exemplary is a late falling wobbler pin which falls after the standing pins are sensed. Existing scorers have no convenient correction facilities for such a readily observable error prior to the time such erroneous information is fed to the computer section.

Further in line with those matters affecting participant acceptance; known scorekeepers do not actually perform any function which the bowler cannot provide himself, i.e., the preparation of a score sheet depicting accurate frame-by-frame subtotal scoring. Indeed, in the absence of circuitry in addition to that required to merely record pin fall data, known scorekeepers would provide less score sheet information than that recorded by manual scoring in the form of "splits," "cherrys" and repetitive or consistent bad ball "patterns."

SUMMARY OF THE INVENTION

The primary object of the invention is to sharply delineate an oversize sensing zone surrounding each correctly spotted pin to insure not only that each correctly spotted standing pin is detected but also to take into account, and permit detection of, those standing pins that may be displaced by pin wobble or the like.

Significant cost savings are realized by the utilization of the novel standing pin sensing system herein described which requires but a single light pulse and its associated circuitry while eliminating the necessity for time delay circuits associated with each of the pin sensing photocells.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial perspective view of a bowling house wherein an adjacent pair of lanes are to be scored by the automatic scorekeeper herein disclosed;

FIG. 2 is a broken elevational view of the pin sensing mechanism in the housed or non-sensing position as it

would appear when viewed from in front of the head pin;

FIG. 3 is an elevational view of the pin sensing mechanism in the extended or sensing position as it would appear when viewed from the pit;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 3 illustrating the intersecting light transmitting and reflecting paths during a pin sensing operation;

FIG. 5 is a schematic top plan view of the pin spot area with the pin sensing mechanism in the position of FIG. 4 and illustrating the enlarged pin sensing zones;

FIG. 6 is a partial top plan view of the console;

FIG. 7 is a sectional view of the pins standing projector;

FIG. 7a is an elevation of the negative used with the projector of FIG. 7;

FIG. 8 is a broken top plan view of the mechanism supporting the scoring head assembly for movement relative to the scoresheet;

FIG. 9 is a front elevational view thereof;

FIG. 10 is a schematic representation of the trochoidal movement undergone by a crosshead supporting the scoring head assembly;

FIG. 11 is an enlarged broken sectional view taken on the line 11—11 of FIG. 8 showing the scoring head assembly in contact with the scoresheet;

FIG. 12 is a similar view taken on line 12—12 of FIG. 8;

FIG. 13 is a broken sectional view taken along line 13—13 of FIG. 11 and illustrating the lost motion connection between the crosshead and scoring head;

FIG. 14 is a partial sectional view taken along line 14—14 of FIG. 12;

FIG. 15 is a section taken along line 15—15 of FIG. 13 and illustrating the mounting of the scoring head assembly photosensitive pickups and the lost motion reciprocal driving connection between the slit slider and shuttle in one extreme position thereof;

FIG. 16 is a similar view showing the opposite extreme position of the slit slider and shuttle;

FIG. 17 is a schematic illustration of the sensing system drive motor circuit;

FIG. 18 is a schematic illustration of the sensing system flash lamp circuit;

FIG. 19 is a schematic illustration of the circuit arrangement including the pin sensing photosensitive elements and their associated SCR's;

FIG. 20 is a schematic illustration of the error correction circuitry;

FIG. 21 is a schematic illustration of the scorer drive motor circuit;

FIG. 22 is a schematic illustration of the printed scoring of one bowling line;

FIG. 23 is an exploded plan view showing the head mask and slit mask components of the scoring head assembly;

FIGS. 24 and 25 illustrate a score logic operation chart for scoring the printed frames of FIG. 22;

FIGS. 26 and 27 illustrate a block diagram of the score and print control logic; and

FIGS. 28A - 28M, when assembled in the manner shown in FIG. 28M, illustrate a circuit diagram of the scorer and print control logic of FIGS. 26 and 27.

GENERAL

A schematic illustration of adjacent bowling lanes in-

corporating the automatic scorekeeper concept herein disclosed appears in FIG. 1 which includes an optical pin sensing system 10 adjacent the pin spot area, as well as score computer, projection and data printing systems housed in a console 12 conventionally positioned for the projection and display of scores on screen 14.

In general, the pin sensing system detects the pin fall after each ball is rolled and energizes parallel circuits to distinct projection and data printing systems housed in console 12. The output from pin sensing system 10 triggers the projection system to project a map of standing pins onto screen 14 and, simultaneously, provides an input to the data printing system resulting in the preparation of a permanent record indicative of "standing pins" and, subsequently, a permanent record print-out of the score as the scoring for each frame is completed. These permanent records may then be projected onto screen 14 in conventional fashion. Following print-out of the standing pin array and prior to the print-out of the score for each frame, scoring logic circuit means is energized which, in conjunction with scanning and optoelectronic pick-ups, computes the score for a particular frame. This information is then transmitted to the printing system for print-out of the individual frame scores.

That data print-out, scanning and optoelectronic pick-ups are housed in a scoring head assembly 16 (FIGS. 9 and 13) which is mounted for traversing movement along each line scoring position of scoresheet 18.

Scoresheet 18 consists of a translucent or transparent substrate upon which has been applied a thin conductive coating such as aluminum on the order of 300 angstroms thickness, for example, which coating may then be arced loose and transferred to the printing electrodes at the area of an electrode contact when a suitable voltage is impressed thereacross between the printing electrode, to be subsequently described, and the conductive surface of scoresheet 18 in conductive contact with scoresheet electrode 19. It is to be noted that the metal coating is typically overlaid by an extremely thin layer of insulating oxide which is penetrated locally by the electrode to initiate the arc.

The constructional details of each of the aforementioned components and their integrated functional relationships to define an automated scoring system will become more apparent from the following detailed description of each system component.

PIN SENSING SYSTEM

The pin sensing system is positioned behind the alley mask and, in its housed or non-sensing position, is totally above the lowermost vertical extent of the mask and is thus shielded from view by the players as shown in FIGS. 2, 3 and 4. A light sensing unit 20 is rigidly supported above the lower level of alley mask 22 in any desired fashion such as by attachment to the conventional light fixture used to illuminate the pin area. A flash illuminating unit 24 is pivotally mounted to housing 26 of the sensing unit for oscillatory movement relative thereto between the positions shown in FIGS. 2 and 3 by a pair of arms 28 mounted on pivot shafts 30, 32 respectively connecting the arms to the sensing and illuminating units. One of the pivot shafts 30 extends through the sensing unit housing and has secured thereto one end of a torque arm 34 the other end of

which torque arm has a pivotal link connection 36 to one end of a crank arm 38 whose other end is rigid with a gear box output shaft 40 driven by electric motor 42. It will be apparent that 360° rotation of output shaft 40 will oscillate the illuminating unit 24 along arc 44 between the positions shown in FIGS. 2 and 3. Two microswitches, M.S. No. 1 and M.S. No. 2, are positioned on the sensing housing and have their respective switch arms positioned to engage a support arm 28 of the illuminating unit housing in its upper housed position of FIG. 2 and arm 34 in the pin sensing or extend position shown in FIG. 3. Depression of M.S. No. 1 deactivates drive motor 42 while the depression of M.S. No. 2 activates the flash illuminating unit 24.

The path of movement of the automatic pin spotting sweep 46 is schematically indicated in FIG. 4 and forms no part of the present invention other than the necessary integration of physical movements undergone thereby in relation to those of the pin sensing system wherein magnets 48 activate a magnetic reed switch 52 to energize motor 42 as a function of the movement of pin sweep arm 50 past the magnets.

Illuminating unit 24 houses an elongated flash lamp 54 which, from the lower position of FIGS. 3 and 4, directs an envelope of light 56 upwardly to illuminate each of standing pins 58 through a directing flash mask 60 and cylinder lens 62. The pattern of pin illumination is indicated by the hashed areas 64 in FIG. 4 illustrating the clearly delineated upwardly directed path of illumination.

Light sensing unit 20 includes 10 photosensitive elements 66; one for each of the 10 pins. The 10 photosensitive elements "look" through three lenses 68, 70, 72 at their individual pins. The spaced horizontal alignment of the lens makes it possible to group three of the photosensitive elements behind each outboard lens 68, 72 and four behind the central lens 70. Appropriate photocell masking, shown in FIG. 5, transmits incoming reflected light from each pin to its individual photocell. Thus the identical lens masks 74 and 76 having three apertures are used with lens 68 and 72 while mask 78 having four apertures is positioned behind lens 70. Thus the middle lens 70 "sees" pins 1, 2, 3 and 5 while the outboard lenses "see" pins 4, 7, 8 and 6, 9, 10 respectively, as indicated by phantom lines in FIG. 5.

With all of the pins standing and the illuminating unit in the lower position of FIG. 4, the flash illumination pattern of FIGS. 4 and 5 will activate all 10 photocells 66 to indicate ten pins standing. Similarly, the failure of any of the 10 photocells to "see" its individual pin indicates the same has fallen.

Inasmuch as pin wobble and/or other pin displacement may cause one or more standing pins to be "off their spot," it is necessary to provide, in effect, an optical zone 80 surrounding each correctly spotted pin within which zone the presence of the pin will be detected. Accordingly, the apertures in masks 74, 76, 78 are dimensioned to provide the necessary zone delineation in conjunction with the upwardly directed path of flash illumination. The ability to sharply delineate these oversize zones is greatly facilitated by the substantial vertical displacement of the illuminating and sensing units whereby the optical paths from the illuminating and sensing units are sharply convergent relative to a horizontal plane. Thus each photocell "sees" along a downwardly directed path 82 which may include more

than one pin; however only one of those pins lies in the upwardly directed flash illuminating path and it is the zone 80 defined by the intersection of these two convergent paths that must be occupied by a pin 58 before the particular photocell will produce an output, or standing pin, signal. Plan and elevational schematics shown in FIGS. 5 and 4 illustrate the clear zone separation provided by the convergent optical paths. The relatively long flash lamp 54 insures that a hidden pin will be properly illuminated by the light coming in on either side of the forwardmost or "cherry" pin.

Following the roll of a ball and initiation of a sweep cycle, activation of the illuminating unit is desirably delayed as long as possible to allow wobbling pins to stabilize or fall. Accordingly, the speed of motor 42 is chosen to require approximately 2 seconds to lower the illumination unit following its energization by momentary contact switch 52 activated by the pin sweep which is conventionally energized by a ball roll meaning that the sensing operation will be complete before the automatic pin spotter, normally operating on a 2 1/2 second lowering cycle, reaches the standing pins. Alternatively, the illumination unit 24 may be lowered but the flash unit not activated until the standing pins have been reset after the fallen pins are swept from the pin deck.

Each photocell which is activated by the reflected illumination from a standing pin then gates an SCR 84 providing a parallel input to the standing pin projection and data printing systems. A conventional "foul" detection circuit is illustrated schematically at 86 to gate an SCR 88 upon the detection of a foul to, similarly, provide a parallel input to the standing pin projection and data printing systems (FIG. 19).

The preferred flash lamp and illumination system drive motor circuits are illustrated in FIGS. 18 and 17 respectively.

PINS STANDING PROJECTION SYSTEM

The pins standing projector 90, housed in console 12, includes ten lamps 92 individually in circuit with an SCR 84 gatable by one of the pin sensing photocells 66, and two manually operable lamps indicating error and foul. The lamps 92 thus illuminated are indicative of the standing pin array which array is then projected onto screen 14 through condensing lens 93, a negative 94 and projection lens 96. Negative 94 contains a printed pin map, error and foul symbols as illustrated in FIG. 7a. The circuit arrangement is shown in FIGS. 19 and 20.

A time delay is provided between the time an SCR 84, 88 is gated and the time scoring head assembly 16 is moved into printing position to provide sufficient time for error switch 98, or foul error correction switch 100 to be depressed if an error should be noted in the projected pin map or foul scoring. The time delay is desirably provided by designing the gear reduction unit associated with the illuminating system output shaft 40 to consume the desired time in reaching its housed position as shown in FIG. 2. Alternatively, a time delay may be provided in the scoring head assembly drive motor as will be subsequently explained. Depression of the "error" button will deactivate the scoring head assembly drive motor circuit until the error is corrected, after which time returning button 98 to the FIG. 7 position will reactivate the motor circuit in a manner to be subsequently explained. The pin map switch array 102

on console 12 consists of momentary contact switches 104 the depression of which will reverse the projected data for the particular pin whose switch is depressed. Thus if the number 3 pin is actually standing but the pins standing projection through lens 96 shows the same as fallen; the error switch is depressed to deactivate the data printing system and switch 104 corresponding to the number 3 pin is depressed to illuminate the number 3 pin lamp. The corrected data is then transmitted to the data printing system.

Scoring head assembly 16 is unable to print-out the pin fall data until such time as the head is driven to the appropriate frame location by the scoring head assembly drive motor, the circuit for which is shown in FIG. 21. Suffice to state, at this point in the description, that the "error" button 98 controls switches 106 in series connection between a D.C. source, the scoring head drive motor and the "error" lamps.

It will be noted that switch 106 is normally closed to the drive motor circuit (FIG. 21) through lead 108 and normally open to the error lamps. (FIG. 20).

Each of the momentary contact switches 104 are double pole double throw switches which upon depression act to reverse the projected data in the circuit schematic of FIG. 20 and will be described in connection with the head pin data projection lamp 110. Assuming a standing head pin were sensed, gating of the appropriate SCR 84 would energize the head pin lamp 110 through lead "Y" in the circuit arrangement shown in FIGS. 19 and 20. In the event the head pin had actually fallen, the projection of the pin map array on screen 14 would portray the error. Error button 98 would then be depressed opening the circuit to the scoring head drive motor (FIG. 21) and energizing the error lamp 112 (FIG. 20). In order to correct the projected data prior to the time the scoring head drive motor is again energized by the return of button 98 to the position of FIGS. 20 and 21 so that corrected data will be supplied to the data printing system; momentary contact switch 104 is depressed. Depression of switch 104 interrupts the current to lamp 110, and SCR 84 associated with the head pin sensing circuit ceases to conduct. Simultaneously, the switch connected negatively charged side of capacitor 114 is transferred to the side of capacitor 116 which is connected to the gate of SCR 118 in the normal switch position of FIG. 20. Therefore, when switch 104 is released to restore the circuit condition of FIG. 20, SCR 118 does not conduct because of the negative gate polarity. Thus, lamp 110 has been switched from "on" to "off."

If the head pin were not sensed as "standing" then the appropriate SCR 84 would not be gated, lamp 110 would be "off," and capacitor 114 charged to approximately 8 volts through line 120; the switch connected end being positive. Depression of switch 104 transfers a portion of this charge to capacitor 116 and upon release of the switch to restore the circuit condition of FIG. 20, SCR 118 conducts since it is gated with a positive polarity from capacitor 116 thus switching lamp 110 from "off" to "on."

It will thus be apparent that the aforescribed circuit functions serve to reverse the "on" or "off" status of each of the lamps 92 irrespective of its initial state. Following the necessary corrections, button 98 is returned to the position of FIGS. 20 and 21 so that the scoring head drive motor may move the scoring head

into a print-out position as will be subsequently explained.

SCORING HEAD ASSEMBLY

The scoring head assembly houses the data print-out electrodes, scanning masks and optoelectronic pickups. Head assembly 16 is mounted on cross-head 122 for vertical movement relative thereto and for trochoidal motion therewith which trochoidal motion results in the traverse of the head assembly across a scoresheet at the position of the particular bowling line to be scored.

The scoresheet contact surface 124 of scoring head assembly 16 is best shown in FIG. 23 and includes an apertured head mask 126 rigidly secured to the head assembly, fixed spaced digital and symbol electrode printing areas 128, 130 and a pair of movable line styli electrodes 132, 134. The aperture pattern of the head mask includes five complete pin arrays or maps 136, four "ball played" sensing apertures 138 in spaced alignment with the line styli electrodes and seven symbol sensing apertures 140 which are appropriately aligned with the "mark" and foul electrodes on the symbol electrode printing area 130. The digital electrode printing area includes three seven-bar digits 142 each of which bars constitutes a separate electrode that may be energized by the data printing circuit to print-out any digit from zero to nine when the same is in contact with a grounded vaporizable conductive coating. Symbol electrode printing area 130 includes three "mark" symbols 144, three foul symbols 146, a frame delineation symbol 148 and two pin maps 150. Each pin map is defined by ten selectively energizable circular electrodes 152. It will be noted that the right-most "mark" symbol 144 includes separately energizable cross-bar electrodes 154, 156 for the selective scoring of a spare or strike.

An apertured slit mask 158, mounted for limited reciprocal movement behind head mask 126, includes five slit pairs 160 adapted to cooperate with the five pin maps 136 in head mask 126 to scan a pin array previously printed out on score sheet 18 by the pin map electrodes. The smaller of each slit pair 160 is aligned with the head pin position while the longer of each slit pair is aligned with the remainder of the map pin positions. Four "ball played" apertures 162, adapted to cooperate with the corresponding apertures 138 in the head mask and two print control apertures 164 complete the aperture pattern of the slit mask. The reciprocal movement undergone by slit mask 158 relative to the head mask is limited to that travel sufficient to permit each slit pair 160 to traverse its single associated pin map pattern in the head mask from a point on one side thereof, where there is no registration between the slit pairs and pin map, to a corresponding point on the opposite side of the pin map. During this transversal of the slit mask, the slit pairs sequentially bring into registry single ones of the pin map apertures with one or the other of the slit pairs. Stated differently, whatever optical pin map pattern appears on the scoresheet below head assembly 16 is scanned during the aforesaid limited traversal of the slit mask.

The symbol electrode printing area 130 leads the pin map apertures 136 in the direction of traversing movement across the scoresheet which is from left to right as viewed in FIGS. 22 and 23. Accordingly, a particular pin map has been printed on the scoresheet in advance

of that time the same is to be scanned. The printing of such map, it will be recalled, resulted in the removal of discrete circular areas of the opaque coating from the optically transmissive substrate as indicated, for example, in FIG. 22, by the small circular transparent areas 166 defining the map 168 of pins left standing by the first ball roll in the first frame. Thus, when one of the apertured pin maps in head mask 126 overlies a particular map print-out of standing pins on the scoresheet, such as map 168, discrete optical paths are defined by the registration of map slits 170 and the etched or printed map 168 on the score sheet. These optical paths extending upwardly from a conventional projection light source housed in console 12 are initially blocked by slit mask 158 but are permitted to sequentially expose the five photosensitive pick-ups 172 which are mounted for limited reciprocal movement relative to head assembly 16 along with the slit mask in a manner which will be subsequently explained. Suffice to say, at this point, that each slit pair 160 in slit mask 158 is constantly aligned with a single photosensitive pick-up and the traversal of such slit pair across its associated pin map 136 in head mask 126 operates to scan the underlying standing pin map print-out 168 on the scoresheet. The relationship of each photosensitive pick-up 172 to its associated slit pair 160 is indicated by the circular phantom lines in FIG. 23. This scanning movement produces from zero to 10 pulses in the circuit from pick-ups 172 which provide the input data to logic circuit 174.

The slit mask 158 is secured to the undersurface of a block-like element, of slit slider, 176 which is mounted for limited movement relative to scoring head assembly 16 to permit the scanning of the printed score sheet pin maps as previously explained. Vertically aligned with each of the five slit pairs 160 is one of the photosensitive pick-ups 172 housed in machined bores in slit slider 176. Smaller bores house additional photosensitive pick-ups 178 in vertical alignment with the "ball played" and print control apertures 162, 164. Seven machined bores in head assembly 16 house additional photosensitive elements 179 functioning as symbol sensors for the "mark" and "foul" symbols printed out by the symbol electrode printing area as shown in FIG. 16.

The reciprocal movement which may be undergone by slit slider 176 is limited by the engagement of shoulder 180 with the spaced stop abutments 182 on the head assembly. For reasons which will become subsequently apparent, it is desirable to utilize a lost motion driving connection to reciprocate the slit slider which lost motion connection may take the form of a shuttle 184 (FIG. 11) mounted for over-travelling reciprocal movement relative to the slit slider. Shuttle 184 includes spaced body sections 186, 188 integrally joined by a reduced shaft portion 190 and adapted to slide on slit slider ways 192, 194. Washers 196, 198 loosely mounted on shaft 190, are biased apart by compression spring 200. One of the washers will always bear against one of the shoulders 202 on the shuttle body while the other will engage one of the recess end walls 204 in the slit slider. As the shuttle moves to the right from the position shown in FIG. 15, spring 200 will extend until such time as washer 198 engages recess end wall 204 at which time the other washer 196 will be engaged by shoulder 202 on the shuttle body. As the shuttle continues its rightward movement the bias of spring

200 acting between the shuttle and slit slider will move the slit slider to the right until it engages stop shoulder 182 after which time further rightward movement of the shuttle will merely compress spring 200 thus permitting the overtravel of the shuttle, in either direction, relative to the slit slider.

As previously mentioned, scoring head assembly 16 is mounted for limited vertical movement relative to cross-head 122 through the intermediary of pins 206, oversize slots 208 and compression springs 210. The purpose of this latter lost motion connection is to insure that proper pressure contact is maintained between the various printing electrodes and the scoresheet.

The manner in which precise reciprocal movement is imparted to the slit slider in synchronization with and as a function of the trochoidal traversing movement of the scoring head, all under the influence of a single rotary input, will now be described.

A support rack 212 (FIGS. 8, 9, 11 and 12) has secured thereto vertically spaced slide rods 204 extending through bearing sleeve mountings formed in a traversing frame 216. Linear traversing movement is imparted to frame 216 by the engagement of spaced pinions 218 meshing with a rack 220 fixed to support rack 212 and extending through suitable bores in the traversing frame. Selective rotation is imparted to pinions 218 via coaxial shaft extensions 222 of eccentrics 224 which, in turn, are rotated by a reversible electric motor 226 whose output gear meshes with a gear 228 secured to a shaft supporting opposed coaxial worms 230 driving gears 232 secured to the forward eccentric shaft extension 222. Cross-head 122 is journaled on the spaced eccentrics 224 so that as the eccentrics are rotated in eccentric unison by motor 226 carried on frame 216, the cross-head will undergo a circular motion relative to the traversing frame in which the eccentrics are journaled for rotation about the axis of shaft extensions 222. It will be thus apparent that the combined linear translation and rotary motion imparted to the cross-head supported scoring head 16 by the traversing frame and cross-head, respectively, describes a trochoidal curve 234 of the type illustrated in FIG. 10. Strictly speaking, it is the cross-head which undergoes the pure trochoidal movement since the downward movement of the scoring head along the loop portion 236 of the curve, as indicated in FIG. 10, is arrested just prior to its completion of the loop portion by virtue of its contact with the scoring sheet at point 238 on the curve. The cross-head is able to complete the loop portion of the curve against the bias of springs 210 by virtue of the lost motion connection between the cross-head and scoring head. That portion of the trochoidal curve above point 238 represents the translating movement of the scoring head from one frame position to the next during which time it is vertically spaced from the scoresheet.

At that point in time when the scoring head comes into contact with a new frame position (at point 238 on the trochoidal curve) it is necessary for the slit mask to be in one extreme position wherein a slit pair 160 is on one side of a pin map and to be translated to the other side thereof during the dwell period of scoring head 16 which is that time interval during which the cross-head is undergoing movement relative thereto along the lower portion of the trochoidal loop as indicated at interval 240. The mechanism for producing this synchro-

nized movement of the slit slider and its integrally attached slit mask is best shown in FIGS. 11-13 wherein one end of a rod or slit flicker 242 is pivoted on a pin 244 at an upper central location on cross-head 122 relative to eccentrics 224. The central portion of slit flicker 242 is closely embraced by a slotted rod 246 whose opposed ends 248 are journaled in traversing frame 216. The lower reduced end 250 of the slit flicker is slidably received in a central bore of barrel bushing 252 rotatably housed in a suitable shuttle recess. As will be apparent, slotted rod 246 functions as a combined fulcrum and slide guide for the slit flicker as the upper end of the slit flicker is caused to move in a circular path relative to the traversing frame 216 in which rod 246 is journaled due to its pivotal connection through rod 244 to the cross-head. The circular motion imparted to the upper end of slit flicker 242 translates into a reciprocal motion of shuttle 176 as the direction of force application at pivot pin 244 is reversed at approximately each 180° in the rotation of the eccentrics 224. The slotted rod 246, of course, oscillates under the influence of the reversed force application to the upper end of the slit flicker. The barrel bushing is similarly oscillated in its supporting recess as the angular inclination of the slit flicker varies to reciprocate the shuttle.

At that point in time when the slit flicker is vertically disposed and the eccentrics are rotating clockwise from the position illustrated in FIGS. 11, 12, 13, the upper end of the slit flicker will move to the left and upwardly which movement is accommodated at the fulcrum by rotation of the slotted rod and its sliding engagement with the slit flicker. This produces a rightward movement of the shuttle, as viewed in FIG. 13, which rightward movement continues during the first approximately 90° rotation of eccentric 224 and then translates in the opposite direction during the next approximately 180° movement of eccentric 224. The shuttle then begins its translation back to the left which is continued through the next approximately 180° rotation of eccentric 224. This reciprocal shuttle motion produces a lesser reciprocal motion in slit slider 176 through spring 200 as previously described.

It will be recalled that the shuttle overtravels with respect to the slit slider in both directions of motion. One reason for the overtravel is that it is necessary to choose the throw of eccentrics 224 to produce the desired trochoidal path to insure that the position of scoring head engagement with the scoresheet will correspond to the next frame position. Since this eccentric throw produces a larger circular path at pivot pin 244 than is necessary to translate the slit slider between its permissible travel limits, the spring bias lost motion connection, previously described, is utilized to insure that the slit slider does, in fact, reciprocate fully between its limit stops. Another reason for the overtravel arrangement between the shuttle and slit slider is that the scoring head must rest in a stationary position on the scoresheet for a limited time when the pin maps are scanned and the various electrodes are energized whereas the drive motor 226 and driving components are constantly driven. Because of the lost motion connection, the scoring head dwell or its time interval of stationary positioning on the scoresheet in printing and sensing position, may extend for approximately 80° of eccentric 224 rotation. Thus, during the rightward traversing movement of scoring head 16 across the score-

sheet, the head may remain stationary at each frame position during approximately 80° of the rotation of the eccentrics 224; the continuous rotary movement of the eccentrics being taken up by the lost motion connections including springs 200 and 210 during the 80° dwell time of the scoring head.

A latching plate 254 (FIG. 14) pivoted at 244 to cross-head 122 has a pair of part circular cut-outs 256 whose radius exceeds that of the two eccentrics 224 which they embrace as shown in FIG. 14. The eccentrics are each provided with six circumferential grooves 258 corresponding to the position of six line scoring positions on the scoresheet. Latch 254 may be tilted about the axis of pin 244 as indicated in FIG. 14 to enter grooves 258 to lock the cross-head in position relative thereto. Latch 254 may be tilted about the axis of pin 244 to a vertical position so that the cut-outs 256 clear grooves 258 after which time the cross-head may be removed to a new frame of scoring position. The cross-head and scoring head may be thus repositioned between any one of six line positions depending on the number of players who are bowling together.

The control circuit for the scorer drive motor 226 is normally activated by the return of the flash illuminating unit 24 to the rest position. As it nears the rest position, the flash illuminating unit momentarily activates a microswitch 260 (FIGS. 2 and 21) to complete a circuit through a time delay unit 262 and a multiple pole switch 264 to the scorer drive motor 226. As previously indicated, a time delay period between the time that an SCR 84, 88 is gated and the time when the scoring head assembly is moved into printing position may be provided by designing a gear reduction unit associated with the illuminating system output shaft 40 to give a desired time delay. If this is done, the electronic time delay unit 262 may be eliminated. However, in the absence of such gear design, any suitable electronic time delay unit 262 may be provided to furnish a delay period between the activation of the micro-switch 260 and the energization of the scorer drive motor.

The scorer drive motor operates to drive the head assembly 16 across the scoresheet 18 in the manner previously described, and during head dwell at each frame scoring position, optical sensors scan the scoresheet to obtain input data for both a data printing control system and computational and output data printing systems. Upon initial movement of the head assembly before the printing areas 128 and 130 thereof have reached the scoring area of the sheet, an elongated blade 266 (FIG. 8) controlling the operation of input print area micro-switch 272 is contacted by a roller 270 which is mounted on the frame 216 and is movable therewith. The micro-switch 272 is connected to prevent input data from being printed when the roller is in contact with the elongated blade 266, and therefore no printing occurs in the name column of the scoresheet 18 (FIG. 22).

The scoring head assembly travels from the rest position past the name column on the scoresheet and the trochoidal advance of the head drive continues until the pin maps 150 on the symbol electrode printing area 130 rest on the scoresheet at the first frame position. In this position, the roller 270 acting through blade 266 permits the input print area micro-switch 272 to activate input data printing circuits to be subsequently described. Similarly, when a further head advance of three frames occurs, a score area switch 268 permits

power to flow into the controls for the digital printing electrodes whose position will then correspond with the first frame.

As the head assembly moves into contact with the score sheet, a head-down switch 274 is actuated by an eccentric roller 276 mounted upon one end of one of the shaft extensions 222 (FIG. 11). The eccentric roller operates through a spring loaded switch actuating rod 278 to activate the head-down switch just before the head assembly contacts the scoresheet.

With the symbol electrode printing area 130 in position so that the pin maps 150 thereof are in the first frame position of the scoresheet, the photosensitive pickups 178 are in position to sense the presence or absence of the two "ball played" lines which will have been previously printed in this frame by the line styli electrodes 132 and 134 if all the balls for the first frame have been rolled. The first space (either first or second ball) within a frame in which a ball played line has not been drawn will be printed with input data. Thus if no lines are sensed in a frame, missing data is printed for the first ball rolled in the frame. On the other hand, if the first line, corresponding to the first ball of the frame, is present in the frame and the second line is missing, only data for the second ball rolled in the frame is printed. Finally, if neither line is missing, no print is made in that frame since input data was previously recorded therein.

The indication printed in any particular frame by the pin maps 150 is determined from data provided by the output from the photocells 66 in the pin sensor 10. However, if all pins were knocked down and no foul has been sensed, the output from the pin sensor causes a gate to condition the input print logic control circuit so that a strike or spare symbol will be printed rather than a pin map. This symbol is selected in response to the output from the photosensitive pickups 178 for the lines printed by the line styli electrodes 132 and 134, the frame position switch 280, 282 output and in frame 10, the results of the previous ball rolled in the frame. Thus, if all pins are knocked down (i.e., none are sensed), no foul has been sensed and no lines are sensed in the frame, a strike symbol is printed by a mark symbol electrode 144 to indicate that all pins were eliminated with the first ball. On the other hand, if the first ball played line is sensed in the frame, the first ball has been rolled and a spare symbol will be printed by the cross bar electrode 156 if all pins are down and no foul has been sensed. An exception to this printing of a spare symbol occurs when the first line is detected in a frame and all pins are missing on the second ball rolled in the tenth frame if a strike symbol has been printed on the first ball. In this situation, the cross bar electrodes 154 and 156 are activated to print a second strike symbol. This is accomplished through the operation of a tenth frame map printing switch 280 which is activated by the roller 270 when the input data printer reaches the tenth frame on the scoresheet. The tenth frame map printing switch, an eleventh frame map printing switch 282, a ninth frame scoring switch 284, and a tenth frame scoring switch 286, are sequentially actuated by the roller 270 when the appropriate sections of the head assembly reach the ninth and tenth frames to alter the electronic circuitry of the printing and scoring sections to accommodate the unique scoring format of the tenth frame.

The input data from one ball only is printed on each traverse of the head assembly, and the frame delineation symbol 148 is printed as a vertical line on the score sheet between frames wherever the information from the first ball rolled during that frame is printed. This does not occur in the tenth frame where the frame delineation line is omitted in the bonus ball position to make this position appear to be a continuation of the first two pin map positions of the frame. The tenth bonus frame is also referred to as the eleventh frame in this description.

In the tenth frame, a strike on the first ball in the frame causes only the line styli electrode 132 to be energized thereby printing out only the first ball line on the score sheet, while in all other frames both the first and second ball lines are printed when the strike is rolled in order to prevent a second ball data print out in that frame. In the tenth frame, however, it is possible to have one, two or three strikes. This fact is accommodated by the tenth and eleventh map printing frame switches 280 and 282 and associated logic which allows printing of all combinations in frame 10.

A foul input to the input print logic from the foul sensor 86 will cause a foul symbol to be printed by the electrode 146 below the position of the symbol corresponding to the particular pin map position, and a full complement of ten pins will be printed on the scoresheet.

During the traverse of the head assembly 16 across the scoresheet 18, the scoring operation occurs several frames behind the map print frame, as indicated in FIG. 23. When the head is positioned so that the digital electrode printing area 128 and the first two pin map scanning positions adjacent thereto are over the first frame position on the scoresheet, photosensitive pickups 178 are in position to sense the presence or absence of the second ball line in the first frame previously inscribed by the line styli electrode 134. The outputs from the photosensitive pickups 178 and the photosensitive symbol sensors 179 for the mark and foul symbols indicate the presence or absence of the markings which are necessary to the scoring logic. If sufficient balls have been rolled to complete the scoring logic for the frame, the logic determines the appropriate pin map to scan, and the stroke of the slit slider 176 causes pulses to be transmitted from the pins printed in that map and entered into the logic. The score to be credited to a frame consists of a multiple of ten pin counts depending on the symbols involved in the scoring logic and the ten-complement of the standing pins in the appropriate printed pin map.

If the scoring logic is complete (i.e., sufficient balls rolled), the digital score is printed out. The value to be printed is stored in an electronic counter whose content is used as an input to a set of decoders and drivers for the three seven bar digits 142. The decoders convert binary coded decimal (BCD) numbers stored in the counter to outputs suitable for constructing the required digits by a conventional seven bar method. The drivers provide electronic switching of sufficient current carrying capability to operate the digit printer.

A digital print out will occur only if two conditions in addition to completed scoring logic have been met. One is that a digital print out was not previously accomplished in the frame being scored. This is determined by the presence or absence of a score as determined by the photosensitive symbol sensor 179 positioned be-

hind the 'TC' symbol sensing aperture 140 one frame ahead of the seven bar digits 142 (FIG. 23). The associated circuit for this sensor, being positioned one frame ahead of the digit printer, remembers the presence or absence of a digit print during one frame advance. In the tenth frame, this same sensor is used to scan for the uniquely positioned, possible strike symbols which would be printed if a strike occurred on the third ball of the tenth frame. This third ball is referred to as the eleventh frame in the logic description.

The second condition which must occur before digital printout is for the slit slider 176 to have completed its stroke. This is determined by the actuation of a slit slider finished switch 288 (FIG. 8) (which is caused by the motion of the projecting end of the slit flicker 242) when the slit slider has reached the end of a stroke. This allows the energization of the digit printer and digital print-out to occur as the printer leaves the scoresheet.

On each successive scoring traverse, the head assembly scans and computes the score cumulatively from the first frame, but prints out only in the completed frames which have not previously been printed. Reversal of the head travel occurs at the completion of the traverse when the frame 216 contacts a stop 296 which operates through a rod 294 to reverse the switch contacts of the multiple pole switch 264 (FIG. 21) and thereby reverse the direction of rotation of the scorer drive motor 226. The motor now reverses to drive the head back across the scoresheet to the rest position where the frame 216 contacts a second stop 296 to actuate switch 264 and again reverse the contacts of the multiple pole switch 264. A switch 298 concurrently breaks the motor circuit and stops the scorer drive motor 226. At this time the headstart switch 298 is momentarily actuated interrupting power to the pin sensor SCRS 84, foul sensor SCR 88, and full map driver 372 (See FIG. 28*h*) thereby resetting the sensor assemblies and the input printout drivers. The headstart switch also contains a third pole which is used to ground one input to the OR gate 1003, new frame flip flop 328 and sense control flip flop 330 thereby resetting the logic.

SCORER AND PRINT CONTROL LOGIC

The sensing and printing functions performed by the scoring head assembly 16 will become more apparent from a consideration of the scorer and print control logic for the head assembly illustrated in FIGS. 26, 27 and 28A-M. For purposes of description of the frame by frame operation of the scorer and print control logic, assume that the bonus fall in the tenth frame of a game has just been thrown to provide a strike, and a whole line of the score sheet has been previously printed in preceding frames with the exception of the tenth frame score and bonus ball pin map. After the bonus ball is thrown and the scorer motor start micro-switch 260 is activated as the sensing cycle is completed, the head assembly 16 travels from the rest position past the name column on the score sheet 18 until the pin maps 150 rest on the score sheet at the first frame. In this position, the input data print area switch 272 enables map printing control section 300. Since no pins were sensed by the pin sensor 10 due to the strike which was rolled, the output of a NOR gate 304 is "high" or a logic 1 indicating all pins down. The output provided by this gate is fed to an inverter 306, one

input of an AND gate 308, one input of a NAND gate 310, one input of AND gate 384 and one input of printer drivers 356 and 358. A logic 1 signal from the NOR gate 304 indicates that a strike or spare symbol is to be printed. Since printing has previously occurred in the first frame of the scoresheet 18 the photosensitive pickup units 178 sense the lines previously drawn by the line styli electrodes 132 and 134, and the presence of these lines causes an input signal to appear at the inputs X1*m* and X2*m* of the scorer and print control logic circuit. The signals at the terminals X1*m* and X2*m* are amplified, inverted and converted to logic levels 312 and 314, respectively, the output from the amplifier 312 being directed to the input of a NAND gate 316 and also through an inverter 318 to the input of NAND gates 320 and 324. The output from the amplifier 314 is directed to inputs of the NAND gates 316 and 320 and also through an inverter 322 to an input of a NAND gate 324. When marks or lines by the line styli electrodes 132 and 134 are sensed in the first frame, the signals at the inputs X1*m* and X2*m* (causing low or 0 outputs at 312 and 314) inhibit both the NAND gates 316 and 320, and since these gates are not turned on, a high level or logic 1 output signal is provided from each. Since neither NAND gate 316 or 320 is providing a low level output to the input of a A/B ball flip flop circuit 326, this flip flop does not change state. Similarly, a new frame flip flop 328 connected to the outputs of the NAND gates 316 and 320 does not change from an "old frame" to a "new frame" state. The new frame flip flop was set to the "old frame state" by the activation of Headstart switch 298 which is connected to one input of the new frame flip flop and also to the input of a sense control flip flop 330 and OR gate 1003. In the "old" state of the new frame flip flop a low or logic 0 output is provided from the new frame flip flop to the inputs of an AND gate 338 and an AND gate 340. Thus the input to the AND gate 340 is a "low" and the output thereof is also a "low" or logic 0. Similarly, the input and output of the AND gate 338 is a "low" or logic 0, and the inputs provided to AND gates 342 and 344 by AND gate 338 are also low. Thus the outputs of the AND gates 342 and 344 are "low" or logic 0, and no output pulse is provided by any of the AND gates 340, 342 and 344. As these AND gates provide the strobe signals for activating a pin spot printing control unit 346 which in turn activates selected electrodes 152 of the pin maps 150 and symbols, no map printing on the scoresheet 18 will occur in the absence of strobe signals from these AND gates.

It is apparent that as long as lines provided by the line styli electrodes 132 and 134 are both sensed by the photosensitive pickups 178, the AND gates 340, 342 and 344 will not provide strobe pulses to permit pin map printing. However, once the head assembly 16 traverses to a frame where no printing has previously occurred, the input signals to the logic circuitry preceding the AND gates 340, 342 and 344 are reversed (i.e., X1*m* and X2*m* are not present), and these AND gates provide selective strobe signals for the A ball printing to the pin spot printing control circuit 346.

After a set of input data (pin map plus symbols) has been printed, further printing is locked out by the circuit composed of inverter 332, delay 334, inverter 336 and sense control flip flop 330. The inverters 332 and 336 and delay 334 cause the "old" output 1 to 0 (negative going) transition to be delayed in reaching sense

control flip flop 330. When the transition reaches the input of sense control flip flop 330 it turns off its output which then locks out NAND gates 316 and 320 until the traverse is completed.

If less than 10 pins are knocked down on the first ball rolled in a frame, the photosensors 66 in the pin sensor unit 10 will provide outputs for each pin standing, and these outputs are provided as inputs to pin printing control drivers 348 in driver sections 350a and 350b. These driver sections are connected to print the respective pin maps 150 identified as PSa and PSb in FIG. 28K with pins 1-10.

When pin sensing data indicative of sensed standing pins is present at the inputs to the drivers in section 350a of the pin spot printing control section 346, the output from the NOR gate 304 will be "low" or a logic 0 indicating that a strike or spare symbol is not to be printed. This signal and its complement from inverter 306 output operating through gates 310 and 352 in concert with other conditions operate to control a ball strike flip flop circuit 354. When the output from the A/B ball flip flop 326 is in the A state and the tenth frame switch 280 is actuated and the NOR gate 304 is a logic 0, the ball/strike flip flop is caused to provide a "low" or logic 0 signal to AND gate inputs for driver 356 which controls the energization of the mark symbol electrodes 154 indicated as TB. Similarly, the NOR gate 304 provides a logic 0 input to the AND gate 308, which in turn provides a logic 0 signal to the AND gate input of drivers 360 and 362 thereby inhibiting printing of the mark symbol electrodes 144 and 156 indicated as TA and SB. In the absence of a sensed strike or spare, the drivers 356, 358, 360 and 362 do not provide an activating signal for the mark symbol electrodes 144, 154 and 156 associated therewith.

If printing of the sensed pin data at the driver section 350A is to be accomplished, the photosensitive pickup 178 must not sense a line provided by the line styli electrode 132 in a frame corresponding to a frame of play in which the sensed pins were left standing. Absence of a sensed line 132 causes a "high" signal to be present at the input of the NAND gate 316 when the other conditions are met, the A/B Ball flip flop 326 changes to the A state and provides a "high" or 1 input to the AND gate 342 which results in a strobe pulse being generated at the output of this AND gate. This strobe pulse strobes the drivers 348 in the driver section 350a and causes these drivers to energize selected electrodes in the pin map 150 (PSa). Additionally, the strobe signal from the AND gate 342 is directed to the driver 358 for the mark symbol electrode TC and driver 360 for the mark symbol TA, and if no standing pins had been sensed by the pin sensor 10, this strobe signal would result in activation of either driver 358 or 360 (depending upon the frame) to cause a strike symbol to be printed by the appropriate electrode TA or TC. However, as previously indicated, with standing pins sensed, the drivers 358 or 360 may not be activated.

Similarly, the standing pins are sensed by the pin sensors 10 after the second ball of a frame has been rolled, and pin information data will be provided to the inputs of the drivers 348 in the driver section 350b of the pin spot printing control unit 346. Now line 132 will be sensed by a photosensitive pickup 178 so that an input will appear at the input terminal X1m, but a second line 134 for the frame will not be sensed by a second photosensitive pickup 178, so that an input will not appear

at the input terminal X2m. This combination of input signals causes a "low" or logic 0 signal to appear at the output of the NAND gate 320, thereby causing the A/B ball flip flop 326 to flip to the "B" state thereby causing the AND gate 344 to provide an output strobe signal. This output strobe signal is furnished to strobe the driver section 350b to cause activation of the pin map 150 (PSb) in accordance with the data on the inputs of the drivers 348 of this driver section. Also, the strobe from the AND gate 344 is provided to the AND gate input of the drivers 356 and 362, and would result in a spare signal being printed by the electrode 156 (SB) or a strike signal being printed by the electrodes 154 and 156 depending upon frame number and results of first ball thrown in frame, if no pins had been sensed by the pin sensing section 10.

The A/B flip flop 326 furnishes output signals to the respective strobe generating AND gates 342 and 344 and also an A signal to the inputs of an AND gate 384 and a driver 364 and a B signal to an AND gate 366. When the A/B Ball flip flop is in the A state (i.e., A high) and all strobe is generated by AND gate 340, driver 364 is turned on, and if all pins are down with no foul and the tenth frame is not being printed, AND gate 384 and driver 368 are turned on. An all strobe is generated by AND gate 340 whenever either an A or B strobe is generated. Thus, when the AND gate 342 provides an output strobe pulse to the driver section 350a, the output from the A/B ball flip flop 326 will cause the driver 364 to energize the line stylus electrode 132 and a line will be printed beneath the map PSa on the scoresheet 18. Similarly, when the AND gate 344 provides a strobe output, the output from the A/B ball flip flop to the AND gate 366 causes activation of the driver 368 through AND gate 366 so that the line stylus 134 prints a line in the second portion of the frame on the scoresheet.

As previously indicated, if the foul sensor 86 senses a foul, a complete pin map is printed on the scoresheet. This results from a signal from the foul sensor through an inverter 370 to the input of a driver 372. The driver 372 operates through a diode network 374 to place signals on all of the input lines to the NOR gate 304 and similarly to place input signals on all of the drivers 348 in the pin spot printing control unit 346. The strobe circuit operates in the manner previously described to then strobe the appropriate driver section 350a or 350b to print a complete pin map on the scoresheet.

Also, when a foul is indicated, a foul signal is taken at the input of the driver section 372 and directed to the inputs of respective foul symbol drivers 376, 378 and 380. These foul symbol drivers are connected to receive control signals from the A/B ball flip flop 326 and from inverters 394 and 395, and in response to these signals and the ALL strobe from AND gate 340 in the presence of a foul input from the foul sensor 86, the respective foul drivers operate to drive one of the foul symbol electrodes 146 (FA, FB or FC) to print a foul indication.

A final control element in the map control logic 300 is the AND gate 340 which is connected to the output of the new frame flip flop 328 and also is connected to receive a signal from the head down switch 274 through an inverter 382. Once each print cycle, the AND gate 340 provides a strobe output signal to the symbol print control unit 302 and particularly to the inputs to the AND gate 366, a strike AND gate 384

both of which are connected to the driver 368 through an OR gate, the foul drivers 378 and 380, the driver 364 and an AND gate 386 which is connected to a driver 388 for the frame delineation symbol electrode 148 (X3). The AND gate 386 is also connected to receive the all strobe, the A control output from the A/B flip flop 326 and the not frame 11 signal so that the driver 388 is energized to print the frame delineation symbol on the scoresheet for all frames except the bonus frame.

Once printout in any frame occurs, the head assembly 16 will continue its traverse across the scoresheet 18 in the manner previously described, and print-out in succeeding unprinted frames must be prevented, for these frames will be printed during later traverses of the head assembly. Only one map and symbol print-out during each traverse of the head assembly is assured by the sense control flip flop 330. This sense control flip flop is reset by the new frame flip flop 328 (old) output operating through inverter 332, delay 334 and inverter 336 when the new frame flip flop 328 is set to new state by gate 320 going low. When one of these signals which causes printing is received by the new frame flip flop, the flip flop changes state to reset through the delay the sense control flip flop 330. The output of the sense control flip flop is connected to the inputs of the NAND gates 316 and 320, and thus the sense control flip flop operates to disable these NAND gates to prevent the generation of further strobe pulses during the remainder of the traverse of the head assembly 16. The sense control flip flop is then set at the same time the new frame flip flop 328 resets upon reception of a signal from the switch 298 at the beginning of a new head traverse.

Normally, when a strike occurs on the first ball of a frame, the line stylus electrode 134 is energized simultaneously with stylus 132 by the AND gate 384 (operating through driver 368) which receives a strike signal directly from the output of the NOR gate 304. However, in the tenth frame of the scoresheet when a strike occurs, a signal is provided from the tenth frame map printing switch 280 through an inverter 390 to the inputs of the NAND gates 310 and 352 and the AND gate input of the driver 356. Also, the output from the inverter 390 is provided through an inverter 392 to an input of the AND gate 384. This causes the AND gate 384 to prevent operation of the driver 368 so that the second line stylus electrode 134 is not energized simultaneously with the line stylus electrode 132 when a strike occurs on the first ball in the tenth frame. Also, the provision of the signal from the inverter 390 to the NOR gates 310 and 352 and to the AND gate input of the driver 356 causes the energization of both the drivers 356 and 362 should a strike occur on the second ball of the tenth frame. Energization of drivers 356 and 362 causes the "X" strike symbol to be printed in the tenth frame second ball strike location on the scoresheet 18.

In the eleventh frame, a signal from the eleventh frame map printing switch 282 through inverter 394 to the input driver 358 permits energization of the driver 358 for the mark symbol electrode TC should strike occur in the eleventh frame. Also, the signal from the eleventh frame map printing switch is fed through inverters 394 and 395 to the AND gate 384 and to the AND gate 386 to prevent printout of X3 and X2 in the eleventh frame. The frame eleven high level signal is

fed to foul driver 378 so if a foul occurs in the eleventh frame, the foul driver 378 is activated in the manner previously described to energize the foul symbol FC. For all frames other than the eleventh, driver 388 is energized to print the X3 frame delineation by symbol electrode 148.

Turning now to the scoring operation of the scorer and print control logic, a ten-frame scoring function occurs when the bonus ball in the tenth frame provides a strike. This scoring function will be described in accordance with the printed score illustrated by FIG. 22 and the operational chart of FIGS. 24 and 25. The trochoidal advance of the head assembly continues until the scoring position of the head assembly containing the digital electrode printing area 128 and the symbol sensing apertures 140 is in position over the first frame on the score sheet 18. In this position, the score area microswitch 268 opens energizing the scoring and printing logic circuits 396. Since the second pin map of the first frame must be counted, NAND gate 398 in a pin map sensor selection unit 399 is now conditioned to transmit pulses from a line photosensitive pickup 172 labeled MBIS. The pulses from the photosensitive pickup MBIS pass through non-inverting amplifier 400 and inverting amplifier 402 and an inverter 404 to an input for the NAND gate 398. The remaining inputs to the NAND gate 398 are connected respectively to the output of photosensitive symbol sensors 179 (SBIS, TAIS, FBIS) for the symbol sensing apertures 140. If a spare symbol has not been printed in the first frame, the photosensitive sensor SBIS will provide a low signal which is inverted in an amplifier 406 and fed as a high signal to the NAND gate 398, while if a printed strike symbol is not sensed, the photosensitive sensor TAIS through amplifier 408 will cause high signal to be fed to the NAND gate. The absence of a foul signal will cause the sensor FBIS through an inverting amplifier 410 to provide a "high" signal to the NAND gate 398. A sensed strike, spare or foul signal would prevent the NAND gate 398 from passing pulses from the slit sensor MBIS, but in the absence of these signals, when the slit slider 176 moves, one pulse comes from the sensor MBIS in response to the single standing pin printed in the pin map on the first frame. When the slit slider finishes a stroke, the slit slider termination switch 288 is tripped which, acting through OR gate 526 causes the logic to block further inputs from the slit sensors 179. OR gates 1006 and 526 form a latch which holds the slit slider signal until flip flop 440 and 442 switch state.

The output pulse passed by the NAND gate 398 is fed through an OR gate 410, a NAND gate 412 and an OR gate 414 into a score computer section 416. The score computer section includes a working counter 418 that consists of a binary coded decimal (BCD) counter consisting of flip flop stages 420, 422, 424 and 426 arranged to count in an 1, 2, 4, 8 weighted sequence followed by two connected binary stages 428 and 430. The counter is reset before each frame cycle to a count of 09 so that one pin spot pulse advances the counter to a count of 10. For this scoring situation the total count provided by the counter (stages 420-430) equals the number of pins standing plus nine. It will be noted that the input to the counter from the OR gate 414 is directed to the count input of first stage 420.

The working counter will generally perform two or three counting functions in a manner to be subse-

quently described. These counting functions include counting out 10 or 20 pulses from a clock oscillator 432 connected to the working counter through a NOR gate 456 and a OR gate 414. The working counter also counts the pulses from the sensors 172, and counts the 0 to 10 pulses from oscillator 432 which are necessary to fill the working counter (Stages 420-430) to a value 19 after the slit slider 176 has completed a stroke.

The operation of the working counter 418 is controlled by three flip flop circuits 438, 440 and 442. At the beginning of the scoing cycle for each frame, all the flip flops will be in the same state ($\bar{Q}$) i.e., lines 444, 524 and 522 "low." When the head assembly 16 comes down, an output 444 (QJ) for the flip flop 438, which is a pulse 10 or plus 20 flip flop, goes high (logic 1) if either +10 or +20 counts are required to be entered from the clock oscillator 432 into the working counter 418. The output 444 from the flip flop 438 is directed to the reset (R) input thereof to provide reset steering and also to the input of a NAND gate 446. The output of the NAND gate 446 is connected through an OR gate 448 to the reset input for the flip flop 438.

A second output 452 (QJ) for the flip flop 438 is connected to the input of an OR gate 454, the output of which is fed to a NAND gate 456 connected to the clock oscillator 432. The NAND gate 456 controls the passage of clock pulses from the clock oscillator through an inverter 458 to the score counter 460. The score counter consists of three decade counters, a units decade 462, a tens decade 464 and a hundreds decade 466 interconnected to count to 300. These decades provide a binary coded decimal output which is fed to decade decoders 468, 470, 472 in a score print decoder and driver section 474. These decoders are seven bar decoders which change the binary coded decimal signals from the decade counter units to activation signals for score print drivers 476, 478 and 480. These drivers provide activation signals to energize the appropriate segments A-G in the seven bar digits 142. The driver 476 activates selected segments in a units digit printer 482, the driver 478 activates segments in a tens digit 484 and the driver 480 activates segments in a hundreds digit printer 486.

It will be noted that outputs from the working counter sections 420, 426, 428 and 430 labeled respectively C1, C8, C10 and C20 are connected to the appropriate inputs of NAND gates 488, 490 and 492. The NAND gate 488 receives a control input from the output of NAND gates 494, 496 and 498 through an inverter 500, while the NAND gate 490 receives a control input from the output of an OR gate 502. Also, the output of the NAND gates 494, 496 and 498 are fed to the input of an OR gate 504, while a second input to the OR gate 504 is provided by the output from the OR gate 502 through an inverter 506. The outputs from the NAND gates 494, 496, 498 are low if +10 counts are required while the output from the OR gate 502 is low if +20 counts are required.

The OR gate 504 provides input to a NAND gate 508, the output of which is connected through an inverter 510 to the set (S) input of the flip flop 438. Also the output of the OR gate 504 is fed through an inverter 512 to an input for a NAND gate 514. The output of the NAND gate 514 provides an input to the OR gate 448.

It will also be noted thtt the NAND gates 508 and 514 receive inputs from output terminals 452 (QJ) of

the flip flop 438, 518 ($\bar{QK}$) of the flip flop 440, and 520 ($\bar{QL}$) of the flip flop 442. The NAND gates 488 and 490 receive an input from the output 444 ($\bar{QJ}$) of the flip flop 438, while the NAND gate 492 receives an input from an output 522 ($\bar{QL}$) of the flip flop 442.

When +10 or +20 counts are required from the oscillator 432, the flip flop 438 will have a high or logic 1 output on the output 444 until the required 10 or 20 counts are added, at which time either the NAND gate 488, if 10 counts are required, or the NAND gate 490, if twenty counts are required, is enabled. The output of the enabled gate goes low to turn off the NAND gate 456 from the clock oscillator.

All pulses fed from the clock oscillator to the working counter 418 are also fed to the units decade 462 of the decade counter 460, so that the decade counter advances by the appropriate 10 or 20 counts. After the required +10 or +20 counts have been added and the NAND gate 456 disabled, the flip flop 438 changes state and the output 444 goes low (logic 0) and the count pins flip flop 440 to provide a high (logic 1) output at an output 524 (QK) thereof. The operation of the +10 or +20 flip flop 438 occurs before the slit slider 176 has sampled the first pin position. The working counter 418 is reset to 09 at the resetting of flip flop 438. If neither a + or ± 20 count is required, the count pins flip flop 440 is set to provide a logic 1 at output 524 at the beginning of the scoring sequence.

A high output on flip flop output 524 causes NAND gate 412 to pass sensed pin pulses from the OR gate 410 through the OR gate 414 into the working counter 418. At the end of the slit slider stroke when all pin positions have been sampled, the slit slider termination switch 288 is closed to provide a signal through an OR gate 526 to the set (S) input of the complement pins flip flop 442 and to the reset (R) input of the count pins flip flop 440. This causes the output 524 from the count pins flip flop to be switched to a low (logic 0) level while the output 522 from the complement pins flip flop is switched to a high (logic 1) level. When output 522 goes high, an input is provided to NAND gate 492 to cause an output therefrom which enables the NAND gate 456 to pass clock pulses from the clock oscillator 432 to the working counter 418 and the decade counter 460. Output 522 remains at a high level until the working counter count value reaches 19, at which time the counter outputs to the NAND gate 492 turn the NAND gate output low and cause the cutoff of NAND gate 456. By this method, the tens complement of the sensed pins enters the decade counter. Thus the count in the decade counter represents the pins knocked down, nine in the case of frame one, since only one standing pin was sensed.

The output from the NAND gate 492 at the end of a scoring period passes through an inverter 528 to activate a NAND gate 530 and cause a pulse to be provided through inverter 532 to the input of a NAND gate 534. This is a score completed pulse, and this pulse causes the NAND gate 534 to provide a print score output command signal to a print power control unit 536 if a score had not previously been printed. The print power control unit then strobes the drivers 476, 478 and 480 to energize selected digit electrodes in the digits 482, 484 and 486. Photosensitive symbol sensor 179 (TC [IS + 1]) is placed in a position to sense one frame ahead the digits already printed in the frame being scored, and this sensed digit signal is passed through in-

verting amplifier 602 into the flip flop 538 which stores the digit detected. The output of flip flop 538 is fed to NAND gate 534 to prevent printing over already existing scores. This sensed digit signal is also passed through an inverter 540 to the input of a NAND gate 598A to inhibit the printing if a score already had been printed in this position. When the head assembly lifts from the scoresheet after frame one, the headdown switch 274 opens and the signal condition previously existing from the headdown switch through an inverter 544 and an inverter 546 to inverter 1007 and the set inputs of the flip flop 438 and 440 are altered thereby providing a high or logic 1 level at the output of inverter 1007 and the reset input to flip flop 442 causing a reset and a low or logic 0 output at the output 522 thereof.

The trochoidal drive for the head assembly 16 lifts and advances the head assembly after the first frame scoring is completed to the second frame position of the scoresheet. Each time that the head assembly comes down on the scoresheet, the headdown switch 174 actuates to allow the pin counting process to begin, and when the head rises and advances, this switch conditions the logic for scoring the next frame. In the second frame of the scoresheet, three standing pins have been printed on the pin map for the first ball to indicate that seven pins have been knocked down. A foul and complete map are printed on the second ball map. Thus three pulses from a photosensitive sensor 172 (MAIS) are directed through non-inverting amplifier 548 and inverting amplifier 550 and an inverter 552 to the input of a NAND gate 554. This NAND gate operates in the same manner as the previously described NAND gate 398, and includes inputs connected to a foul symbol sensor 179 (FBIS) through an inverting amplifier 410 and inverter 556 and a strike symbol sensor 179 (TAIS) through the inverting amplifier 408. The output from the NAND gate 554 is fed to the input of the OR gate 410 so that the pin complement (7) is then added to the previously stored (9) count indication from the first frame in the decade counter 460 to reach a total of 16 for the second frame.

When the scoring head assembly moves to the third frame on the scoresheet, a strike symbol is sensed by the symbol sensor 179 (TAIS). This causes a signal to be provided through the inverting amplifier 408 and an inverter 558 to an input to the NAND gate 498. The NAND gate 498 is also connected to receive a second strike signal from a photosensitive sensor 179 (TA [IS + 1]) through an inverting amplifier 560, but in the absence of this signal and the presence of a strike signal TAIS, the NAND gate 498 causes a +10 signal to be provided to the OR gate 504 and through the inverter 500 to the NAND gate 488. The NAND gate 488 in conjunction with other signals then holds the NAND gate 456 open until 10 pulses have been fed from the clock oscillator 432 to the working counter 418 and the decade counter 460. The working counter 418 resets to 09 and a NAND gate 562 allows pulses from photosensitive sensor 172 (MA [IS + 1]) to enter the working counter 418 through the OR gate 410, the NAND gate 412, and the OR gate 414. It will be noted that the NAND gate 562 has an input connected to receive pulses from the sensor MA (IS + 1) through a non-inverting amplifier 1008, an inverting amplifier 564 and an inverter 566. The NAND gate 562 has inputs connected to receive a strike indication from the in-

verter 558 and a foul indication from a symbol sensor 179 (FB [IS + 1]) through an inverting amplifier 568 and an inverter 570. Since the first ball in frame four was a foul and ten pin spots were printed, the complement is 0. Thus only the 10 count is credited to the frame for the sensed strike, making the total scored in the decade counter 460 for the third frame 26.

In frame four, the NAND gate 554 is activated as in frame two. Since 10 spots have been printed in the map sensed by the photosensitive sensor 179 (MAIS) due to a foul, the complement equals zero and therefore the decade counter 460 is left with the stored count of 26.

In the fifth frame, the NAND gate 498 causes 10 counts to be added to the decade counter 460 in the same manner as was previously described in connection with frame three. Subsequently, a NAND gate 572 provides four pulses to the working counter 418 through the OR gate 410, the NAND gate 412 and the OR gate 414. These four pulses are received by the NAND gate 572 from the photosensitive sensor 179 (MB [IS + 1]) through an inverting amplifier 574 and an inverter 576. The NAND gate 572 is also connected to receive a strike input indication from the inverter 558 or the inverting amplifier 560, a frame 10's input, and a foul input indication from the inverting amplifier 568. The four pulse output from the NAND gate 572 causes the complement (6) to be entered into the decade counter 460 so that the total score in the fifth frame becomes 42.

When the head assembly moves into the sixth frame, the NAND gate 398 opens to pass four pulses from the photosensor 172 (MBIS) in the same manner as occurred in frame one. This causes the total score in the decade counter 460 to change to 48 in the sixth frame.

In the seventh frame of the scoresheet, a NAND gate 578 is activated to allow 20 counts to be pulsed into the decade counter 460. This action is controlled through the OR gate 502, the NAND gate 490 and the NAND gate 456. After 20 pulses, the NAND gate 490 closes the NAND gate 456.

The operation of the NAND gate 578 is controlled by inputs received from the inverter 558, the inverting amplifier 560 through an inverter 580, a frame 9's input, a frame 10's input and the output from an OR gate flip flop latch section 582. The OR gate flip flop latch section includes four flip flops, each formed by two OR gates which store the sensed states of the X lines during slit slider travel. The values stored by the OR flip flop latch section are provided by photosensors 178 (X2Is, X1[(IS + 1), X2 (IS + 1) and X1 (IS + 2)) which sense the presence or absence of marks printed by the line styli electrodes 132 and 134. The outputs from these photosensors are fed through inverting amplifiers 584 and inverters 586 to the flip flop latch section 582. As previously indicated, unless marks for two balls are sensed in each frame by the photosensors 178, no score printout will occur. Thus, the outputs stored by the OR gate flip flops in the flip flop latch section during slit slider travel are provided to the input of the NAND gate 578 and also to the inputs of a NAND gate 588, to NAND gates 494, 496 and 542, the NAND gate 498, the NAND gate 534 and NAND gate 596.

After the NAND gate 578 permits twenty counts to be pulsed into the decade counter 460, a NAND gate 590 opens to pulses from a photosensitive sensor 172

(MA [IS + 2]). Normally, pulses from this photosensor are fed through an amplifier 1012 and inverting amplifier 592 and an inverter 594, but in frame seven, a strike was rolled so that no pin map was printed. Thus no pulses are generated so none pass through the NAND gate 590 and the complement of 0 (10) enters the decade counter 460 after the 20 pulse count. The total in the counter in the end of frame seven is now 78.

In frame eight, the scoring procedure is identical to that in frame seven the the same NAND gates are activated. Therefore, at the end of frame eight, thirty more pulses have been added in the decade counter and the total is now 108.

When the digital electrode printing area 128 is in position over frame eight, the symbol electrode printing area 130 of the head assembly 16 is in position over the eleventh frame of the scoresheet where no pin map or ball rolled indication lines have previously been printed by the pin maps 150 and the line styli electrodes 132 and 134. The eleventh frame map print switch 282 is now actuated to prevent the frame delineation symbol printer 148 from being activated through the action of inverters 394 and 395 and AND gate 386. An indication that all pins are down from the NOR gate 304 results in activation of the driver 358 to provide a strike symbol print out by the mark symbol electrode 144 (TC) and the line styli 132 provides a ball rolled line as the slit slider strokes.

The digital electrode printing area 128 of the head assembly now moves to frame nine on the scoresheet, and a NAND gate 596 provides an output to the OR gate 502 to cause the NAND gate 490 to permit 20 pulses to pass through the NAND gate 456 into the decade counter 460. A second NAND gate 598 now opens to pulses from the photosensor 172 (MB [IS + 1]) but because of the second tenth frame strike, no pin spots are seen and 10 more counts enter the decade counter to make the total 138.

In the ninth frame, the ninth frame scoring switch 284 provides a signal through a NAND gate 598A and an inverter 600 to set the flip flop 538 to print digits in the next succeeding frame, since a digit sense signal from symbol sensor 179 (TC [IS + 1]) is not present. This sense signal would normally be provided through an inverting amplifier 602 to the flip flop 538 and through an inverter 540 to the NAND gate 598A. Thus the ninth frame scoring switch causes the logic to look for the unique possibility of another strike in the last map position of the tenth frame.

When the head assembly moves to scoring position in the tenth frame of the scoresheet, the NAND gate 542 causes the OR gate 502 to activate the NAND gate 490 so that the NAND gate 456 passes 20 pulses from the clock oscillator 432 to the decade counter 460 and the working counter 418. Now a NAND gate 604 transmits sensed pulses received thru non-inverting amplifier 1008. Since the tenth frame scoring switch 286 has been activated, the symbol sensors 179 (TAIS), and SBIS which normally detect a spare, are now used to detect a second strike in the tenth frame. A second strike in the tenth frame may be recognized, for a NAND gate 606 connected by an inverter 608 to the output of the inverting amplifier 406, and inverter 558 driven by inverting amplifier 408 are conditioned by the sensing of a first strike.

In the tenth frame, absence of sensed pin pulses from the pin map MA (IS + 1) causes ten more counts to be entered into the decade counter 460. The total in the decade counter is now 168.

The complement pins flip flop 442 now causes the NAND gate 530 to provide a score completed signal through the inverter 532 to the NAND gate 534. The NAND gate 534 provides an output signal to the score print power control 536, and the output from the decade counter through the seven bar decoders controls the drivers 476, 478 and 480, which now cause a digital printout when the head assembly leaves the scoresheet. The digital printout is provided by the electrodes 482, 484 and 486.

The head frame now strikes the reset switch and the head drive drives the head assembly to a rest position at the left of the scoresheet. At this time, the decade counter 460 is reset to zero by a reset signal on line 610.

It will be noted that the logic circuitry connected to the photosensitive sensors 172, 178 and 179 all operate in a manner similar to that described in connection with the scoring of the ten frames heretofore outlined, and therefore the operation of logic circuitry not involved in the scoring of these 10 frames will be apparent from a consideration of the operation of logic circuitry involved in such scoring which is connected to corresponding photosensitive sensors. For example, a NAND gate 612 operates in a manner similar to that described for the adjacent NAND gate 398.

We claim:

1. Pin sensing means for detecting the presence of vertically standing bowling pins at the pin spot end of a bowling lane by the sensing of optical transmissions reflected from discrete areas of standing pin necks or heads contained within non-intersecting zones surrounding each pin spot, comprising: optical transmitting and sensing means for defining optical path means originating in front of the head pin position and converging in the direction of the pit end of the lane, means for positioning one of said transmitting and sensing means below the level of a standing pin head, means supporting the other of said transmitting and sensing means above the level of a standing pin head, and control means for activating said transmitting means whereby optical transmissions reflected from said discrete areas of standing pins will be sensed by said sensing means.

2. The pin sensing means of claim 1 wherein said means for positioning one of said transmitting and sensing means consists of power operated support means mounting said transmitting means for controlled movement between a momentary transmitting position below the level of a standing pin head and an inactive housed position above the level of a standing pin head, control means for activating said power operated support means to position the transmitting means in the transmitting position in response to each ball roll, and said control means for activating said transmitting means being responsive to movement of the transmitting means to the transmitting position.

3. The pin sensing means of claim 1 wherein said sensing means includes individual photosensitive means for each pin spot, and said transmitting means includes a single optical transmitting element for all of said pin spots.

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4. The pin sensing means of claim 3 including an electronic switch individually in circuit with each individual photosensitive element and gatable by the same upon receipt of a reflected transmission from the transmitting means, a scoresheet, and data printout means 5

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in circuit with the electronic switch for printing a map of standing pins on said scoresheet in response to each ball roll.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,795,402 Dated March 5, 1974

Inventor(s) John G. Bolger, Jr. et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 22, line 26, after "+" insert -- 10 --.

Column 23, line 22, "174" should read -- 274 --.

Signed and sealed this 18th day of June 1974.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents