Sept. 20, 1966 F. K. UMBEL 3,274,390

GLASS CUTTING CONTROL APPARATUS

Filed June 16, 1961 8 Sheets-Sheet 1

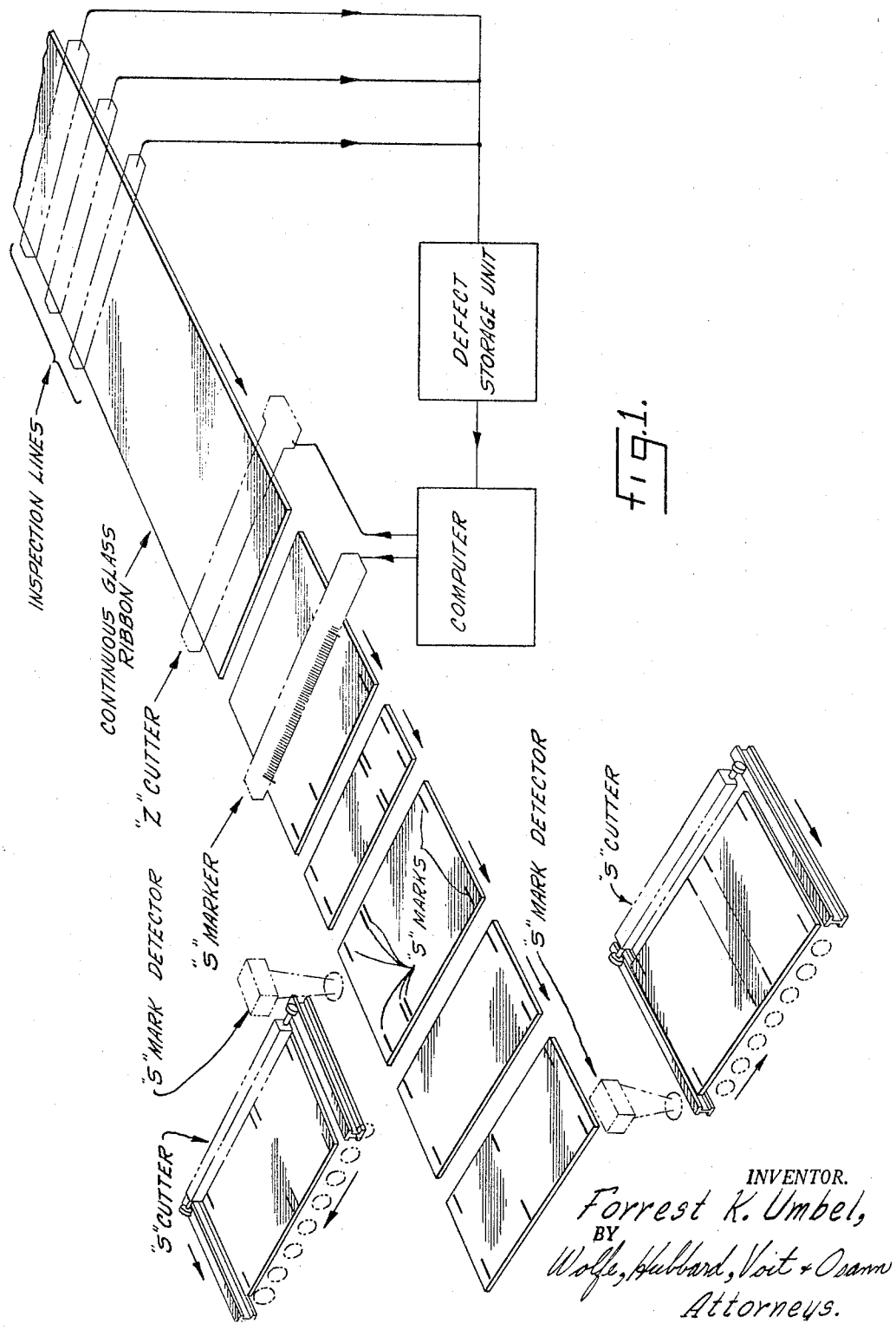


Fig. 1.

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GLASS CUTTING CONTROL APPARATUS

Filed June 16, 1961 8 Sheets-Sheet 2

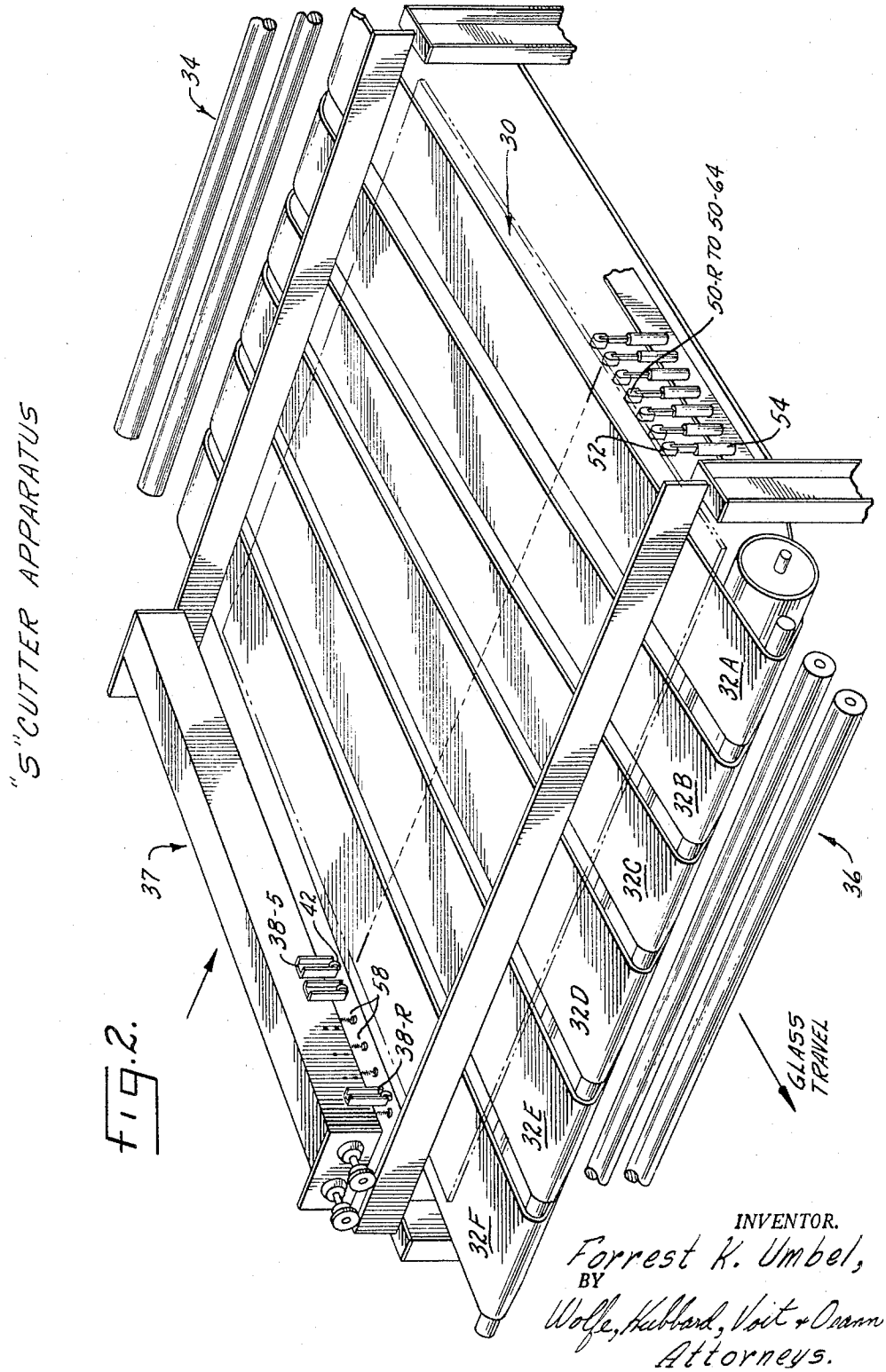


Fig. 2.

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GLASS CUTTING CONTROL APPARATUS

Filed June 16, 1961 8 Sheets-Sheet 3

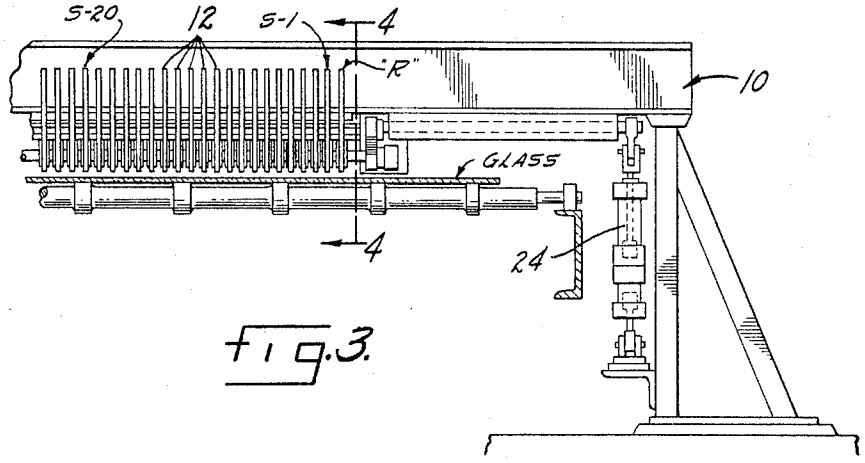


Fig. 3.

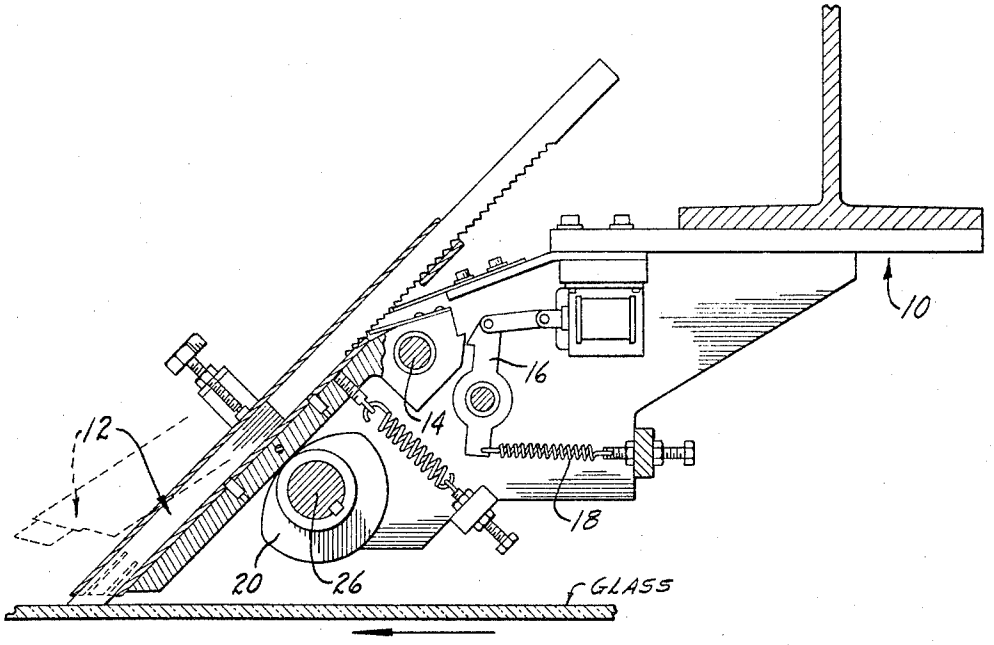


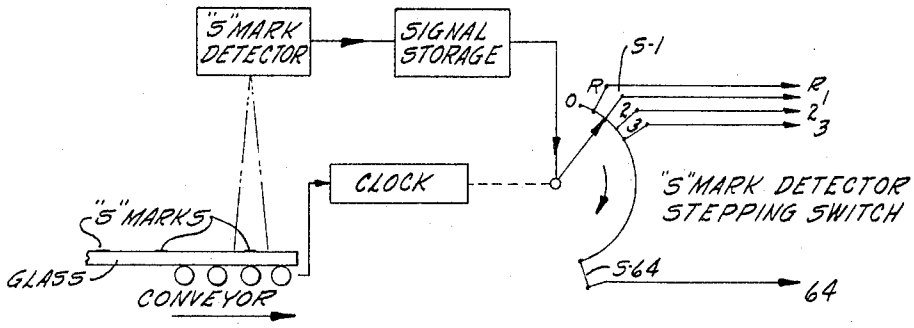
Fig. 4.

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GLASS CUTTING CONTROL APPARATUS

Filed June 16, 1961 8 Sheets-Sheet 4

Fig. 5.



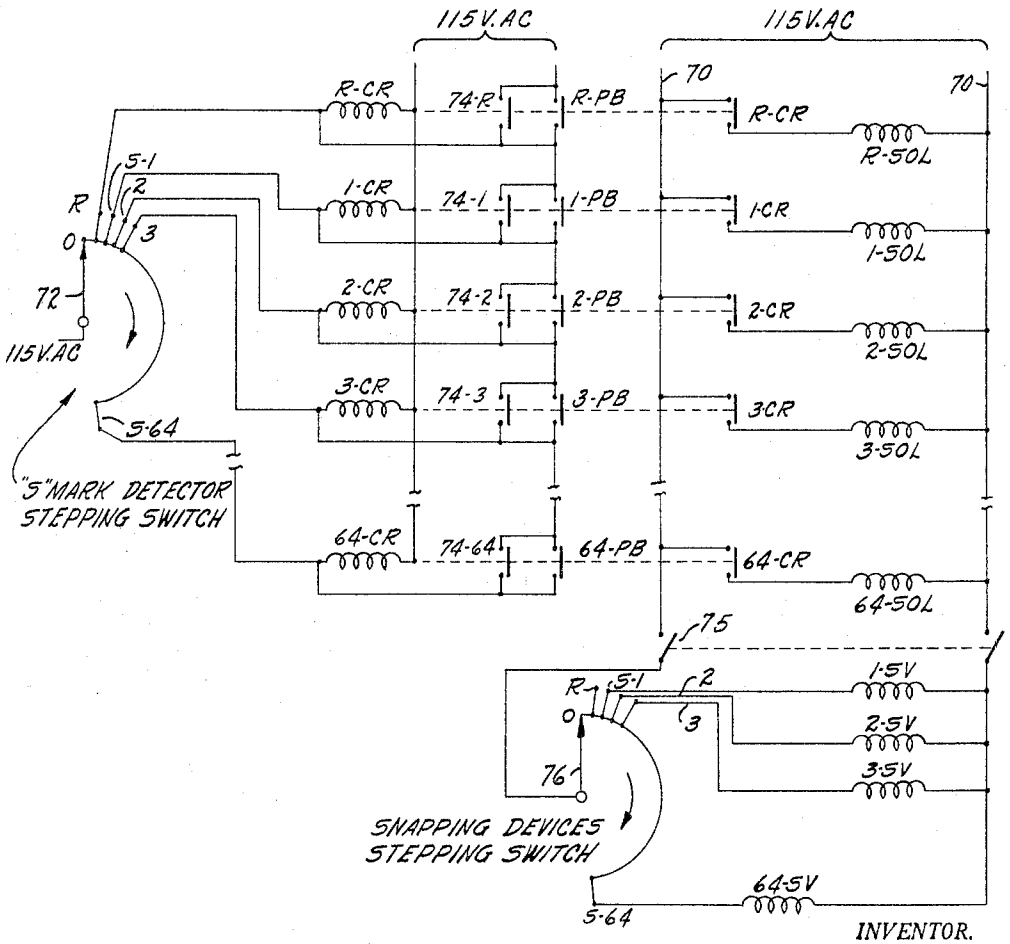


Fig. 11.

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GLASS CUTTING CONTROL APPARATUS

Filed June 16, 1961 8 Sheets-Sheet 5

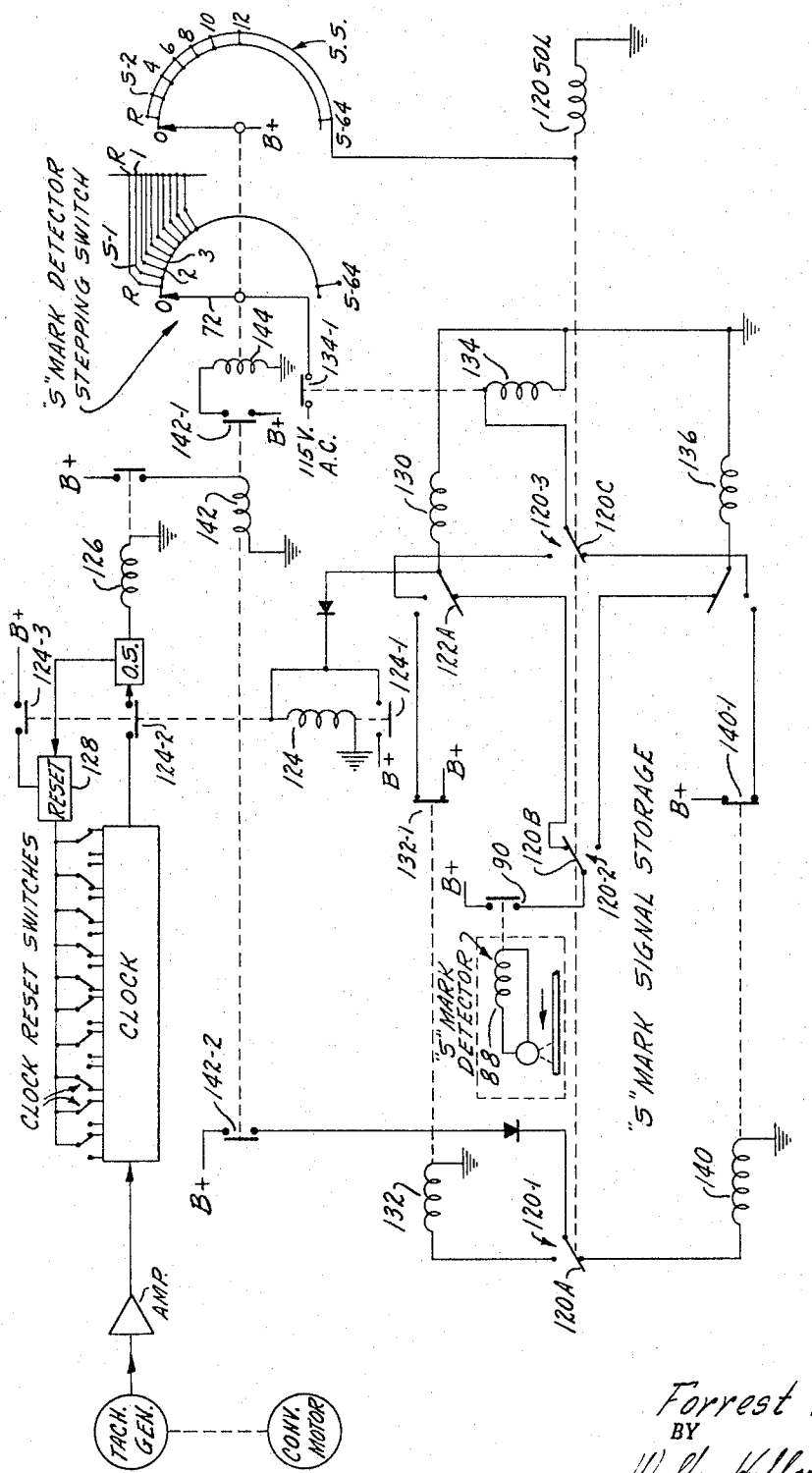


FIG. 6.

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GLASS CUTTING CONTROL APPARATUS

Filed June 16, 1961 8 Sheets-Sheet 6

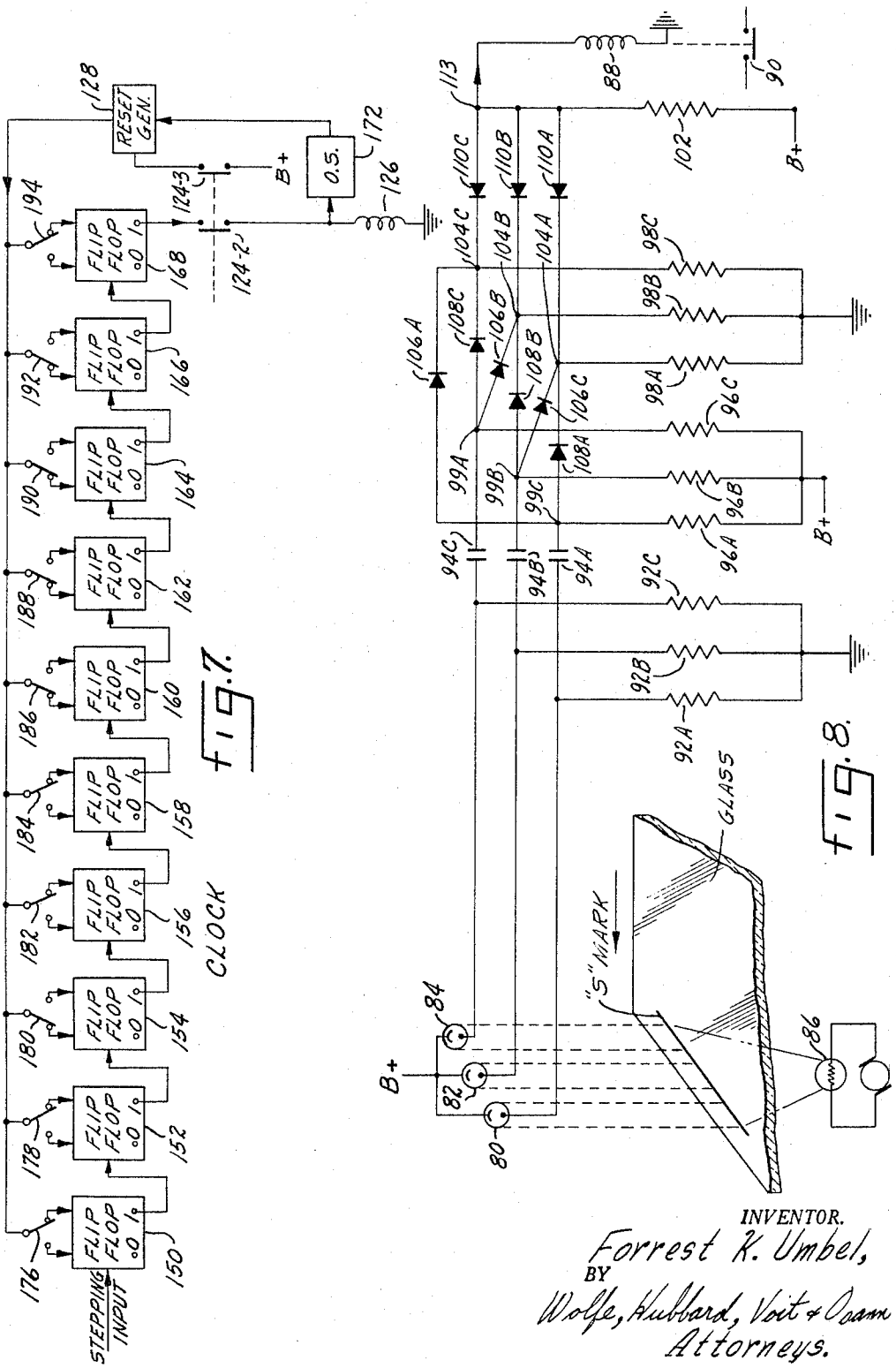


Fig. 7.

Fig. 8.

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GLASS CUTTING CONTROL APPARATUS

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Fig. 10.

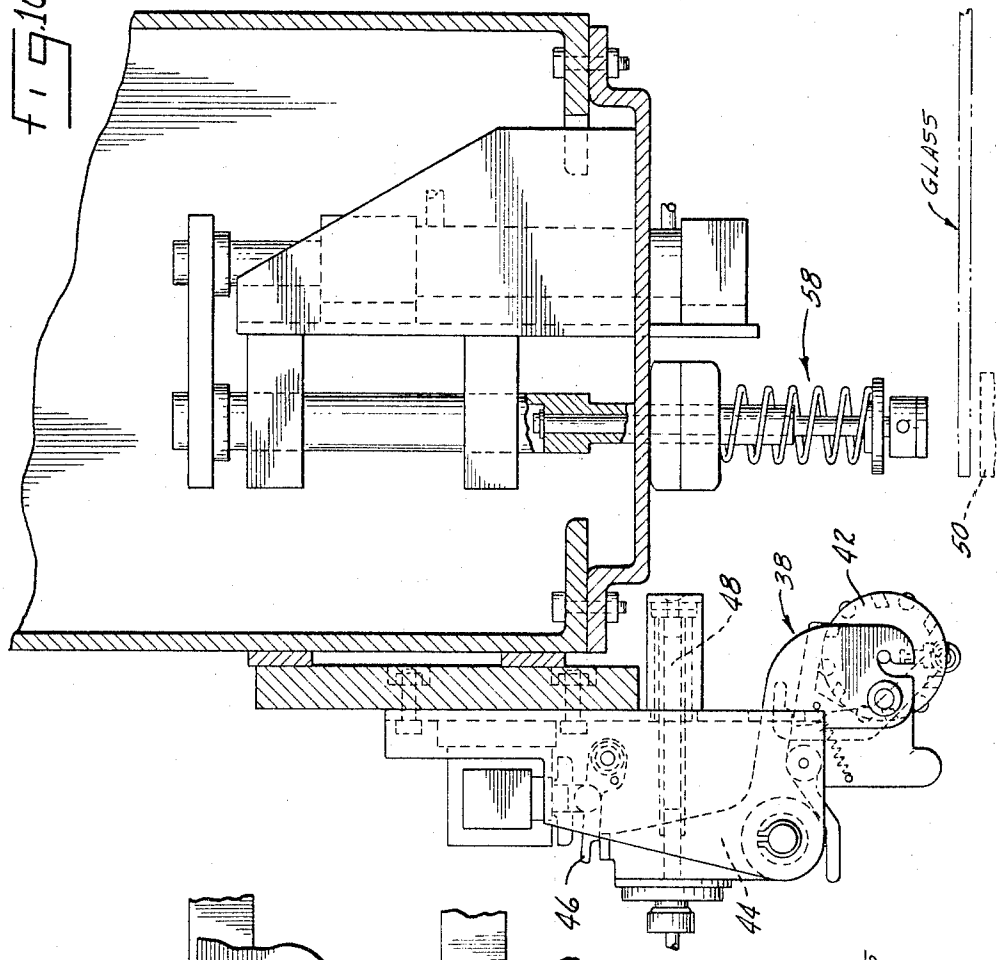
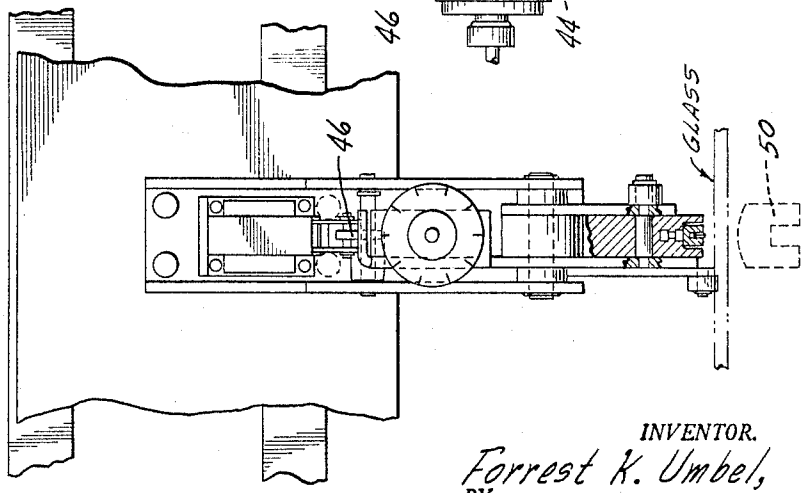


Fig. 9.



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GLASS CUTTING CONTROL APPARATUS

Filed June 16, 1961 8 Sheets-Sheet 8

	CLOCK STAGES																			
	1		2		3		4		5		6		7		8		9		10	
F.F. TERMINALS	"0"	"1"	"0"	"1"	"0"	"1"	"0"	"1"	"0"	"1"	"0"	"1"	"0"	"1"	"0"	"1"	"0"	"1"	"0"	"1"
540 RESET	0	+	0	+	+	0	0	+	0	+	+	0	+	0	+	0	+	0	0	+
1024 RESET	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+
1ST PULSE	+	0	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+
2ND PULSE	0	+	+	0	0	+	0	+												
3RD PULSE	+	0	+	0	0	+	0	+												
4TH PULSE	0	+	0	+	+	0	0	+												
5TH PULSE	+	0	0	+	+	0	0	+												
6TH PULSE	0	+	+	0	+	0	0	+												
7TH PULSE	+	0	+	0	+	0	0	+												
8TH PULSE	0	+	0	+	0	+	+	0												
									↓	↓										
15TH PULSE	+	0	+	0	+	0	+	0	0	+										
16TH PULSE	0	+	0	+	0	+	0	+	+	0										
											↓	↓								
31ST PULSE	+	0	+	0	+	0	+	0	+	0	0	+								
32ND PULSE	0	+	0	+	0	+	0	+	0	+	+	0								
													↓	↓						
63RD PULSE	+	0	+	0	+	0	+	0	+	0	+	0	0	+						
64TH PULSE	0	+	0	+	0	+	0	+	0	+	0	+	+	0						
															↓	↓				
127TH PULSE	+	0	+	0	+	0	+	0	+	0	+	0	+	0	0	+				
128TH PULSE	0	+	0	+	0	+	0	+	0	+	0	+	0	+	+	0				
																	↓	↓		
255TH PULSE	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	0	+		
256TH PULSE	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	+	0		
																			↓	↓
511TH PULSE	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	0	+
512TH PULSE	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	+	0
1023RD PULSE	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0
1024TH PULSE	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+

Fig. 12.

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United States Patent Office 3,274,390 Patented Sept. 20, 1966

3,274,390

GLASS CUTTING CONTROL APPARATUS

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Filed June 16, 1961, Ser. No. 125,329
7 Claims. (Cl. 250—219)

This invention relates to control apparatus for directing the cutting of glass sheet or continuous glass ribbon into a number of smaller pieces.

In the manufacture of glass, the cutting process by which smaller useful sizes are produced from large sheets or continuous ribbon on a glass production line, entails cutting the glass transversely at different locations in a longitudinal, or "Z," direction to produce Z lengths of glass followed by slitting the Z lengths in the opposite transverse, or "S," direction into rectangular pieces. The first transverse Z cuts and the subsequent transverse S cuts are selected in view of desired Z by S sizes and the locations of defects in the glass, to partition the glass into usable rectangular pieces excluding the major defect containing glass areas.

In carrying out this partitioning process, it has been customary heretofore to manually direct the S cutting operation by which Z lengths of glass are slit into the final rectangular pieces. One object of this invention is to direct such a partitioning process such that the cutting of Z lengths into S widths is carried out completely automatically and in pace with the continuous glass production.

Another object of the invention is to set up the S cutter apparatus responsive to a record of S cut locations made on the Z lengths of glass.

Another object is to provide apparatus for detecting S marks on rapidly moving glass sheets and capable of distinguishing such marks from other opaque marks on the glass so as to insure that the S cuts are made only at the proper S locations.

Another object is to provide a control circuit operated by a plurality of photosensitive elements which circuit responds to simultaneous changes of state of selected ones of such elements.

One of the objects of the invention is to provide improved means for accurately synchronizing a series of record derived signals with the movement of the record.

Further objects will appear from the following description taken in connection with the accompanying drawings in which:

FIGURE 1 is a schematic view depicting a glass production line and the flow of glass along a conveyor and laterally on side line conveyors to the S cutter apparatus;

FIGURE 2 is a diagrammatic perspective view of the S cutter apparatus;

FIGURE 3 is a partial elevational view of the S marker apparatus;

FIGURE 4 is a sectional view taken along the lines of 4—4 of FIG. 3;

FIGURE 5 is a block diagram illustrating the components of the S mark detector control circuit;

FIGURE 6 is a schematic wiring diagram of the S mark detector control circuit;

FIGURE 7 is a diagram of the clock operating the S mark detector stepping switch;

FIGURE 8 is a schematic wiring diagram of the S mark detector;

FIGURE 9 is a partial elevational view with parts in section showing details of the S cutter apparatus;

FIGURE 10 is a side view of FIG. 9 with parts in section;

FIGURE 11 is a schematic wiring diagram of the S cutter control circuit; and

FIGURE 12 is a chart illustrating different states of the clock stages.

While the invention has been shown and will be described in some detail with reference to one particular embodiment thereof, there is no intention that it be limited to such detail. On the contrary, it is intended here to cover all modifications, alternatives and equivalents falling within the spirit and scope of the invention as defined by the appended claims.

General organization

Upon more specific reference to the drawings it will be seen that the invention is applied to apparatus employed in the manufacture of glass which may be in the form of sheets 128" wide and 180" in length, or in the form of a continuous ribbon of this same width. In general, the industrial apparatus illustrated provides means for partitioning the glass into usable, saleable sizes, excluding the major defect containing portions. To this end, as illustrated particularly in FIGURE 1, which comprises an overall schematic representation of a glass production line and associated glass partitioning apparatus, the glass is conveyed from a source such as plate glass grinding and polishing apparatus (from right to left in FIGURE 1) by means of a roller conveyor past inspection stations to a glass cutting apparatus for making successive transverse cuts across the glass sheet or ribbon width, herein called Z cuts. The glass conveyor is then speeded up to move or advance the Z lengths forwardly along the conveyor spacing such from the continuous ribbon glass or sheet of glass in the Z cutting apparatus. Such Z lengths of glass are then shunted onto side lines and into S cutter apparatus at a cutting berth in each side line wherein a set of second cuts, herein called S cuts, are made to slit or slice the Z lengths iinto smaller usable widths.

In the copending application, Serial No. 850,360, filed Nov. 2, 1959, of William F. Galey, Joseph A. Gulotta, and Forrest K. Umbel, entitled: Length and Area Partitioning Methods and Apparatus, means is disclosed for automatically deciding the Z and S cuts required to evolve the maximum overall yield of usable glass considering the locations of defects in the sheets or ribbon of glass on a glass production line, such as shown in FIGURE 1, in view of a programmed series of sizes. In carrying out this partitioning process, a secondary record is made of the locations of defects appearing in the glass. Z and S cut decisions are made in the computer based on defect location information derived from the secondary record The Z cutter is operated upon command of the computer responsive to such decisions. Still referring to FIGURE 1, with the illustrative apparatus, also upon command of the computer, marks are placed on the Z lengths of glass as the latter move along the line, indicating the S locations of the S cut decisions. Thus, each glass sheet Z lengths has on its surface a record of the cuts required to complete the partitioning process, in the form of S marks, and such information is carried along with the glass sheet as it moves downstream from the Z cutter toward the S cutter on that one of the side lines to which the glass Z length is selectively shunted.

For details of suitable means for making a secondary record of glass defects, reference may be made to application Serial No. 850,460, now Patent No. 3,191,857, of William F. Galey and George W. Misson.

As described in detail therein, in order to provide the requisite information as to defects appearing in the glass, which information is stored in the secondary record and used in deciding the partitioning of the glass, the glass may be first manually inspected for the presence of de-

fects, or, alternatively, the glass may be optically inspected at inspection stations upstream of the Z cutter. With manual inspection, those defects of such severity as to affect the quality of the glass are dimensionally located by marks placed on the glass. Such defect marks are detected by photosensitive devices mounted over the glass line and dimensional information as to such defect marks is transferred from the detectors to defect storage apparatus for making a secondary record of defect location. While the present invention is not limited to the particular defect detection, defect storage, or Z and S cut computing apparatus hereinbefore described, this invention has particular utility in an automatic glass partitioning apparatus including such components. Turning, therefore, to details of certain portions of the apparatus previously generally described, the S marker construction and operation has particular significance and cooperation with the present invention as will appear from the following.

S marker

Following each computing cycle during which the computer considers the demand program of Z by S sizes and chooses the sizes that give the preferred fit, the Z cutter is operated upon command by the computer to make the successive Z cuts. In order to make the longitudinal S cuts on which the calculations depended for choosing the Z by S sizes and the Z lengths, without interfering with the flow along the conveyor, the severed Z lengths of glass are marked for the S cuts before being shunted onto side lines for cutting by suitable slit or S cutting apparatus. Referring to FIGURES 3 and 4, a preferred means is there shown for placing the S marks on the Z lengths of glass. As hereinbefore mentioned, reference may be made to application Serial No. 850,460, of William F. Galey and George W. Misson, now Patent No. 3,191,857, entitled: Glass Partitioning Process and Apparatus, for details of a suitable S marker apparatus.

As indicated diagrammatically in FIGURE 1, the S marker apparatus is carried on a fixed bridge **10** over the conveyor and is connected by cable to the computer for transfer of the command signals. In this partitioning process the glass is cut in both the Z and S directions to dimensions which are integral multiples of 2". Where the glass on the line is 128" in width, in the present illustrative case, the bridge **10** carries sixty-three individually operable markers **12** for placing marks on the glass defining locations for S cuts at each 2" spacing across the glass. It will be understood that provision may be made for marginal trim cuts of different widths; however, for present description purposes it will be considered that with sixty-three markers all requisite S marks may be made, and an "R" and a sixty-fourth marker are provided, one at each end of the S marker row, for making reference marks designating the edges of the sheet. While the spacing of the markers may be varied as desired, it is advantageous to have the spacing between markers as small as the mechanical considerations permit so that the marks appearing on the glass may be located in a narrow band to gain time in the S mark detection and control of the S cutting apparatus. In the present case, the S markers, including the R and sixty-fourth reference markers, are mounted on 1½" centers so that the spacing between S marks on a Z length of glass is in multiples of 1½". It will be readily understood, furthermore, that while the present apparatus is constructed to operate with 2" as the basic dimensional unit for measuring Z by S sizes, another dimensional unit may be used as desired with suitable mechanical and electrical circuit modifications.

Referring to FIG. 4, each S marker includes a crayon holder pivotally mounted on the bridge **10** by means of a shaft **14**, so that the holder may be moved from a normally raised position (shown in dashed lines in FIG. 4) wherein the tip of the crayon is above the glass, to a marking position (in solid lines in FIG. 4) wherein the tip of the crayon is in glass contact, the movement of the glass producing a mark thereon. The holder for the crayon is normally positioned to maintain the crayon above the glass by a solenoid operated latch **16**. In the present case, the holder is yieldingly biased toward the marking position by a spring **18**. The position of each holder may be adjusted to move the crayon toward the glass marking position by a cam **20** once the solenoid **22** has operated the latch **16** to release the holder. Individual cams **20** are provided for each holder and are rotated through successive positions of a cycle by a hydraulic means **24** connected to a shaft **26** carrying the cams. The solenoid **22** provided for the latch of each holder, is connected individually to the computer so that the command to make an S mark in a particular S location is transmitted from the computer through the connection to the solenoid associated with the marker at that S location.

S cutter apparatus

Now referring to FIGS. 2, 9 and 10, a suitable means for cutting the Z lengths of glass into usable widths, referred to herein as the S cutter, is mounted between continuous sections of each conveyor side line to receive individual glass Z lengths. For details of a suitable S cutter apparatus, as above mentioned, reference can be made to Patent No. 3,146,926, of Charles O. Huffman, George W. Misson, and William F. Galey, entitled: Glass Cutting Apparatus. In the present case, such cutting apparatus includes a table **30** in the form of a plurality of spaced conveyor belts **32A–32F** aligned longitudinally with the side line and separating the incoming side line conveyor section **34** from a following conveyor section **36**. The glass Z length is delivered by the incoming side line conveyor section **34** onto the table **30** where the glass sheet is clamped for the usual scoring and snapping glass cutting operations. A carriage **37** movable transversely of the table and glass Z length carried thereon from a home position shown in FIG. 2 to an away position at the opposite side of the table carries sixty-five individual scoring devices **38**–R to **38**–64 mounted on 2" centers the full length of the carriage. Each scoring device **38** is thus mounted at the location to score the glass sheet for an S cut and 2" from the adjacent S cut scorer. In the operation of the S cutter, selected scorer devices **38** are lowered into glass contact and a full set of score lines is made during travel of the carriage between its home and away positions; subsequently, the glass sheet is snapped at each score line to make the S cuts.

Turning now to details of the scoring devices, referring also to FIGS. 9 and 10, each scoring device **38** includes a scoring wheel **42** pivotally mounted by a lever **44** which is normally held by a latch **46** above the glass. Actuation of the associated solenoid RSOL to **64**SOL raises the latch **46** allowing a spring **48** to pivot the lever **44** and lower the scoring wheel **42** into glass contact. The solenoids RSOL to **64**SOL are selectively actuated by control means hereinafter described in detail.

Below the table **30** (FIG. 2) and located so as to be under the carriage with the latter in the away position is a row of snapping devices **50**–R to **50**–**64**. Each snapping device **50** has a snapping head or caster **52** which may be raised into glass contact. To this end each snapping device also has a hydraulic cylinder **54** operated by a solenoid valve RSV to **64**SV, the hydraulic cylinder being connected to raise the head of the snapping device against the bottom surface of a glass sheet on the table after the sheet has been scored by selected scoring devices during travel of the carriage to the away position to run each cut along the score lines in the glass. For cooperation with the snapping devices **50**, the carriage **30** carries resilient fulcrum elements **58** which are positioned between each of the scoring devices **50**.

Accordingly, a program of S scorer solenoids RSOL to **63**SOL is actuated with the carriage at its home position

on one side of the side line, thereby setting up the scoring devices while the Z length of glass is run into the cutting berth. The glass Z length is scored for all S cuts by driving the carriage, by means of a hydraulic motor, across the glass with all scoring devices of the S cut program or series in glass contact to produce all the score lines. The carriage is driven to its away position wherein the scorers are located past the edge of the glass sheet as shown in FIG. 10, and with the carriage in said position the snapping devices **50** are successively operated to snap the glass sheet at each score line starting with the first snapping device **50**–R adjacent the left side of FIG. 2 and the following conveyor section **36**, and continuing with each successive snapping device until all score lines have been snapped. As each snapping device is hydraulically operated, the caster or head **52** which is between adjacent fulcrum elements **58** lifts the edge of the glass upward into contact with such fulcrum elements. Where a score line is present the snapping head under the glass is aligned with the score line and the upward pressure by the head in cooperation with the fulcrum devices breaks the glass, starting the cut which runs across the sheet following the score line. After the scoring and snapping operations have been completed for an entire glass sheet in the S cutter, the individual widths of glass are run out of the cutting berth onto the following conveyor section **36** and removed from the table by operating the table belts **32**A–**32**F. The carriage **37** is subsequently returned to its home position to await the delivery of a succeeding Z length of glass.

Reference is also made to FIG. 11, a schematic diagram of the S cutter control circuit. The scorer solenoids RSOL to **64**SOL are shown at the right side of the diagram connected between 115 volt A.C. buses **70** in series with relay contacts RCR to **64**CR. The buses **70** are energized from a 115 volt A.C. source through switches, not shown, which are closed by a glass Z length moving into the S cutter and are opened following the cutting operation. The scorer solenoids are energized when S relays RCR to **64**CR are actuated either manually to insert a program of S cuts, by means of push button switches RPB to **64**PB, or in accordance with a series of S marks on the glass Z length moving into the S cutter. In the latter case, according to this invention, by means described hereinafter in detail, a stepping switch is driven in synchronism with the movement of the glass Z length into the S cutter. S mark signals are transferred through the wiper **72** of the stepping switch to the appropriately numbered S relay RCR to **64**CR to set up the scorer devices.

When an S relay RCR to **64**CR is energized by one of the push buttons RPB to **64**PB or through the stepping switch, holding contacts **74**–R to **74**–**64** are closed to seal in the relay coil. The scorer solenoid RSOL to **64**SOL thereby remains energized after the wiper **72** passes the same numbered contact. After the Z length is in the S cutter, means (not shown) may be provided to align and clamp the glass sheet, following which the carriage **37** with the actuated scorer devices is driven across the table **30** to score the glass sheet. When the carriage reaches its away position, it is stopped and a snapping device stepping switch at the lower part of FIG. 11 is actuated to operate the snapping devices **50**–R to **50**–**64** in sequence. Thus the switch **75** is closed by suitable mechanism after the carriage **37** reaches the away position to energize the circuit of the snapping device stepping switch, and the wiper of the latter is driven to its successive positions to run the cuts previously scored. Suitable circuit switches and protective devices will be included to obtain the desired specific order of operations and at the desired speeds, as will readily be understood.

S mark detector control circuit

In accordance with the present invention the S cutter apparatus is set up automatically by the S marks on a Z length of glass, which serve as a record of the S cut decisions. To this end, an S mark detector is mounted above each side line conveyor **34** ahead of the S cutter and adjacent a marginal edge of the conveyor over the series of S marks on a Z length moving into the cutting berth.

As shown in the block diagram of FIG. 5, signals from the S mark detector are conveyed through a signal storage network and an S mark detector stepping switch to the S relays of the cutter apparatus. In keeping with this invention, the clock drives the stepping switch in synchronism with a Z length of glass passing the S mark detector. The first mark on the glass, a reference mark applied by the R marker of the S marker apparatus and representing the edge of the glass accounting for trim cuts, starts the clock operating when carried under the S mark detector by a glass Z length travelling toward the S cutter. It will be recalled that the S marker records the S cut decisions in the form of marks made on the glass at multiples of 1½″ spacings which represent, however, S cuts at multiples of the 2″ dimensional unit. This control circuit is effective to expand the S record on the glass, scaled at multiples of 1½″, to the requisite 2″ cutting scale. In the present case this is achieved by stepping the wiper **72** of the stepping switch to successive positions with each 1½″ of glass movement, so that after the first 1½″ of glass movement following the reference mark, the wiper is shifted to its reference R position; after the next 1½″ of glass movement the wiper is shifted to its S–**1** position, and so on, always lagging one step behind the glass movement. The S–**1**, S–**2**, S–**3**, etc., contacts of the stepping switch are connected to operate the **1**–CR, **2**–CR, **3**–CR, etc., relays of the S cutter, respectively, to operate the same numbered scorer solenoids **1**SOL, **2**SOL, **3**SOL, etc. It will be readily understood, therefore, that an S mark on the glass will produce a signal via the S mark detector which is stored in the signal storage network to avoid missing or misplacing S mark signals between contact positions of the wiper **72**, and this signal is read out of the signal storage network and transferred through the stepping switch to the S relay having the same number as the S mark measured from the reference mark on the glass, thereby to operate the scorer solenoid having the same S number to score the glass sheet at that S location when the carriage **37** of the S cutter is operated. A series of scorer solenoids **1**SOL to **63**SOL is thus set up to carry out the S cut decisions recorded as S marks on the Z length of glass.

As shown in FIGURE 1, it is preferred to operate the S marker to place marks on each Z length adjacent both its leading and trailing edges so that an S mark detector adjacent the same marginal edge relative to glass movement, above either right or left side line conveyors will be passed by a series of S marks.

In general, the S mark detector, which is shown in detail in FIG. 8, comprises a circuit which responds to an S mark passing photosensitive elements, herein shown as three aligned phototubes **80**, **82**, **84**. Such phototubes are illuminated by a light source **86** mounted below the side line conveyor **34** such that any S marks intercept the light beams reducing the illumination of the phototubes. The phototube circuit responds with an output signal which actuates a suitable S mark signalling relay **88** closing its contacts **90**, which are located in the signal storage network.

1. *Mark Detector.*—In carrying out the invention, the S mark detector is responsive to S marks on the glass and is capable of distinguishing such marks from spots or other opaque marks. Stating the function of the S mark detector in another way, where the S marks on the glass constitute bits of data and may be at 1½″ spaced data points within the band of S marks, the S mark detector is capable of producing signals denoting either the presence or absence of bits of data at each data point. For this purpose the S mark detector includes a plurality, herein

shown as three phototubes **80**, **82**, **84**, which are mounted over the glass side line conveyor **34** at a point ahead of the cutting berth and S cutter, as shown in FIGURE 1, and are closely spaced in alignment transversely of the direction of glass movement. The phototubes are located adjacent one margin of the conveyor above the S marks on a glass sheet thereon so that a line on the glass representing an S mark intercepts the light from below the glass illuminating all three phototubes producing, under such conditions, a reduction in illumination of all three phototubes. To discriminate between an S mark line and an opaque or dark spot on the glass, an S mark will be represented by dark signals simultaneously at any two of the three phototubes in the circuit, and will produce an output signal, while a dark signal at only one phototube produces no output signal.

Also referring to FIGURE 1, the first mark R on a glass sheet moving along a side line conveyor is a reference mark and represents the marginal cut to be made; other marks define the S cut locations in terms of the 2" dimensional unit; that is, S–17 represents 34" and S–35 represents 70" from the reference mark. Such S marks are shown for purposes of illustration, crowded into a band of marks on the glass wherein the marks appear at multiples of 1½" spacings, and thus such marks are not at the actual locations of the S cuts to be made. With this arrangement to gain time in the S direction, all S cut information may be read from the glass sheet to set up the S cutter apparatus before the sheet is completely into the cutting berth. It will be understood that the S marks herein shown as lines may be any opaque line or mark applied on the glass by means such as a washable crayon.

Still referring to FIG. 8, the three phototubes **80**, **82**, **84** used in this preferred circuit are of the photo-resistive type, having a significantly lower resistance when illuminated; that is, when connected to a source of D.C. operating potential conventionally shown as B^+, and normally illuminated through a glass sheet by the light **86** below the conveyor. The resistance of such a phototube increases, representing a dark signal, responsive to a reduction in illumination of the phototube. The three phototubes **80**, **82**, **84** are each connected in a first circuit position in series with a resistor **92A** to **92C**, providing a first set of parallel resistors, and to ground, with each resistor having a similar resistance value to that of the initial (illuminated) resistance of the phototube. The same potential appears at the junction points between the phototubes **80**, **82**, **84** and the resistors **92A** to **92C** with the phototubes uniformly illuminated and such junction points are connected through condensers **94A** to **94C** to a second circuit portion including second and third sets of parallel resistors **96A** to **96C**, **98A** to **98C**, respectively, connected in series between a source of D.C. potential B^+ which may be the same potential source energizing both circuits, and ground. For illustrative purposes, a satisfactory circuit is provided using resistors with a resistance value of 100K ohms for the first and second sets of parallel resistors, and resistors with a resistance of 200K ohms for the third set, where the initial (illuminated) resistance of the phototubes is 100K ohms.

The parallel resistors **98A** to **98C** of the third set are also arranged in series with a resistance **102** illustratively of about 2 megohms and a source of D.C. potential shown as B^+ to operate a suitable signalling device, herein shown as a relay **88** in the signal storage network. This relay **88** is operated by a negative pulse reflecting a drop in potential in any one of three conductors at points **104A** to **104C** responsive to a dark signal at any two phototubes.

To this end, the phototube circuit of FIG. 8 operates in the following manner. In the normal condition of the circuit, with all portions energized, when light from the source **86** is falling on all three phototubes, current flows from B^+ through each phototube **80**, **82**, **84** and the first set of resistors **92A** to **92C** causing the same potential to appear at the junction points therebetween and the left hand terminals of all three condensers **94A** to **94C**. Likewise, current flows from B^+ through the second and third series connected sets of parallel resistors **96A** to **96C** and **98A** to **98C**, with the same potential appearing at the junction points therebetween. With the same potential source used for both such circuit portions, and the resistance values noted hereinbefore, in the initial illuminated condition of the phototubes **80**, **82**, **84**, the junction points in the second circuit portion are maintained at a slightly higher potential than the phototube junction points, since a proportionally greater voltage drop occurs across the third set of parallel resistors **98A** to **98C** with such current flow due to the higher value of such resistances, thereby charging the condensers to the potential difference prevailing between the respective junction points, which potential difference is less than the supply voltage B^+.

When the first reference mark "R" intercepts the light illuminating the phototubes **80**, **82**, **84**, the effective resistance of two and usually all three phototubes increases from the initial value to a markedly higher value, illustratively 1 megohm. With an increase in resistance of any phototube, a proportionally greater voltage drop occurs across the phototube effective resistance as compared with the voltage drop across the resistance **92A** to **92C** in series with the phototube, causing a drop in potential at the junction point therebetween and effectively clamping the left-hand terminal of the affected condensers **94A** to **94C** substantially to ground potential, so that the potential at the second circuit junction points **99A** to **99C** is reduced to the charge then existing on the affected condensers. The affected condensers will then draw current from the second B^+ potential source to charge the condensers toward the potential B^+ and hence will return the voltages at the second circuit portion junction points **99A** to **99C** connected to the affected condensers to the voltage previously thereon, producing in effect a negative pulse at the junction points.

In order to produce an output signal responsive to darkening of at least two phototubes, the circuit is arranged including diodes **106A** to **106C** and diodes **108A** to **108C** to block the transfer of any signal through to the output terminal **113** unless at least two of the condensers **94A** to **94C** are affected by change in illumination on the associated phototubes. Thus if only one phototube **80** is darkened due to the passing of an opaque spot rather than a line, the left-hand terminal of the affected condensers **94A** will drop to substantially ground potential thus tending to drop via the diode **108A** the potential at the point **104A**. But with the other phototube **82** still illuminated, and the associated condensers **94B** being maintained at the prevailing higher voltage, the point **104A** will be maintained at that higher voltage via the conducting cross connection diode **106C**. In a like manner with a reduction in illumination of any one but not two of the phototubes, the points **104A** to **104C** will be held at the high potential prevailing at the second circuit junction points **99A** to **99C**.

In the event, however, that two of the phototubes **80** and **82** are darkened due to the passing of a line, then the left-hand terminals of both affected condensers **94A** and **94B** will be clamped to substantially ground potential, and via the conducting diodes **108A** and **106C**, the lower potential at the second circuit junction points **99A** and **99B** due to the charge on these condensers will be conveyed to drop the potential at the point **104A**.

Such a drop in potential at any one of the points **104A** to **104C** has the effect of rendering the associated diode **110A** to **110C** conductive to bypass current from the source B^+ and the resistor **102** and away from the high impedance output relay **88** thus, in effect, producing a negative pulse which is transferred from the output terminal **113** to the relay **88**. Bypassing current from the

relay 88 will have the effect of deenergizing the relay 88, causing it to close its contacts 90 producing an S mark signal. It will be noted that a higher impedance output device herein shown as a relay 88 is employed to insure that the potential at the point 113 is higher than the substantially ground potential pulse transferred through from the junction points 109A to 109C when two of the phototubes are darkened due to passing of a line thereby rendering the diodes 110A to 110C conductive to cause bypass current to flow.

In this manner the S mark detector phototube circuit responds to an S mark in the form of a crayon line on the glass which produces a change in excitation of at least two of the three phototubes 80, 82, 84 in the circuit, but is not responsive to an opaque mark or spot producing a change in excitation of only one phototube.

2. *Signal Storage Network.*—The details of a preferred circuit for the signal storage block of the FIG. 5 block diagram, appear in the schematic diagram of FIG. 6. Referring to this latter figure, therefore, for the following more detailed description of this storage network, the network is energized by sources of D.C. operating potential conventionally shown as B^+, which are connected into the network by suitable switches (not shown) when a Z length of glass moves into the inspection zone of the S mark detector before reaching the S cutter.

In general, to carry out this invention, the signal storage network includes two circuit portions to which incoming S mark detector signals, representing S marks on the Z length of glass moving past the detection, are alternately conveyed, and from which the same S mark signals are alternately read out and transferred through the S mark detector stepping switch to the S relays of the S cutter.

More in detail, S mark signals are transferred alternately to the circuit portions, and such circuit portions are alternately read out and erased, by a switch 120 having three sets of contacts 120–1, 120–2, 120–3 and operated by a solenoid 120SOL. The latter solenoid in turn is operated by a stepping switch SS, which may be a second level of the S mark detector switch, operating in synchronism with the glass movement. Only alternate, herein shown as the even numbered, contacts of such stepping switch are used and these contacts S–R, S–2, S–4, etc., are connected to the solenoid 120SOL. With this arrangement, with the stepping switch SS wiper arm on its odd numbered contacts, the solenoid is deenergized moving the switch arm 120A to 120C to the position shown in FIG. 6, and with the wiper arm on its even numbered contacts the solenoid 120SOL is energized to move the switch arms 120A to 120C to their other positions.

In the operation of the signal storage network, an incoming signal representing the first reference mark R on the glass Z length caused by the S mark detector relay 88 closing its contacts 90, is transferred through the switch arm 120B and 122A to a holding relay 124. The latter relay closes one set of contacts 124–1 to seal in the relay, a second set of contacts 124–2 to connect the output terminal of the clock in circuit with the clock output relay 126, and a third set of contacts to energize a reset generator 128 for resetting the clock stages to their reference state. The clock, in the present case, produces an output pulse for each 1½" of movement of glass past the S mark detector, which pulse is used to step the stepping switch wiper arm 72 from position to position synchronized with the glass movement. Thus the first clock pulse received after the clock is reset to its reference state steps the wiper 72 to the contacts labelled R. Each clock output pulse automatically resets the clock by means of the reset generator 128, so that the clock output pulses remain in step with the glass movement. The subsequent clock pulse steps the wiper to the contacts labelled S–1, S–2 and so on.

Referring again to the incoming reference mark signal, such is also conveyed through the switch arm 122A to a signal relay 130 which shifts the switch arm 122A to its upper position thereby connecting the relay 130 to a potential source B^+ through the erase contacts 132–1, and sealing in the relay 130. When the stepping switch SS is shifted to the R position in unison with the S mark detector stepping switch, the solenoid 120SOL is energized shifting the switch arm 120C to its read out position. With the signal relay 130 energized and holding the reference mark signal, a pluse is transferred from the potential source B^+ through the erase contacts 132–1, the raised switch arm 122A to a read out relay 134. The latter closes its contacts 134–1 in the circuit to the wiper arm 72 of the stepper switch thereby sending a pluse over conductor R to energize the reference relay of the S cutter relays.

With the solenoid 120SOL so energized, an incoming S mark detector signal representing an S mark at the first S position, is conveyed to the other signal relay 136 which holds the signal until read out when the switch 120C returns to the position shown in FIG. 5 upon deenergization of the actuating solenoid 120SOL at position S–1 of the stepping switch SS.

The erase relays 132 and 140 are energized to drop out the signal holding relays 130 and 136, respectively, opening erase relay contacts 132–1, 140–1. Illustratively, with the network in the condition shown in FIG. 6, when the first clock pulse is emitted, which shifts the signal storage network to read out the R signal, the clock pulse momentarily energizes a second relay 142 which is effective to close one set of contacts 142–1 energizing the stepping switch rotor 144, and to close a second set of contacts 142–2 in a circuit including the erase coils 132, 140. Closing the latter contacts 142–2 momentarily energizes the erase coil 140, with the circuit in the condition shown, to release the associated signal holding coil 136. With switch arm 120A in its raised position, an erase signal is conveyed in a similar manner to the erase coil 132 to release the signal holding coil 130 after read out.

3. *Clock.*—With the S marks on the glass lengths in multiples of 1½" spacings, each of a series of signals produced by the S mark detector is fed via an individual channel to the S cutter scorer solenoid 1SOL to 63SOL at the S location corresponding to the position of the signal along a time base determined by the speed of glass movement. This is achieved in the present case by the S mark detector stepping switch and the clock which generates synchronizing signals or pulses to move the stepping switch from position to position in synchronism with the glass movement. As hereinbefore described, each S mark of a series on a glass length is detected, producing a signal which is automatically transferred through the stepping switch to the proper relay of the S cutter.

With particular reference to FIGS. 6, 7 and 12, the clock function may be served by various known circuits. By way of example, the clock is here shown in FIG. 7 to comprise series connected bistable multivibrators, conventionally shown as flip-flop devices. The clock has ten of such bistable means 150 to 168 forming ten stages with the output terminal of the tenth stage being connected to a monostable multivibrator, shown as a one-shot 172 which, upon receipt of a pulse from the tenth clock stage, fires the output relay 126 and transmits a pulse to the reset generator 128 connected to the reset terminals of each clock stage.

With all ten stages of the clock set to the same reference state, one output pulse is transmitted from the tenth stage after the receipt of 1024 input pulses. The clock thus includes ten stages representing successive places of the input pulse binary number as successive powers of 2.

Still referring to FIG. 7, the clock is driven in the present case by a continuous square wave input signal of a fixed frequency. A source of such an input signal may be a tachometer generator driven in synchronism with a side line conveyor 10 as by a drive connection to the conveyor motor. The tachometer generator output is connected through suitable means for squaring and amplify-

ing the generator pulses, herein shown as an amplifier, to the first stage of the clock.

One of the features of the present invention is the provision of means to adjust the frequency of emission of synchronizing pulses produced by the clock with a high degree of accuracy, thereby accommodating very slight variations in speed of glass movement.

To adjust the frequency of the synchronizing pulses or signals supplied by the clock, means is included in the reset circuit for selectively setting each clock stage to an initial 0 or 1 state thereby to set the reference state of all stages of the clock to the binary representation of any decimal number from one to 1024.

In the present case, and by way of illustrating this invention, it is desired to set the clock to produce one output pulse per inch and one-half of glass movement into the cutting berth. It will be readily appreciated that for a given glass conveyor line speed, over short periods of time the speed of glass movement is uniform, but over extended time periods the glass speed may vary slightly due to bearing wear or change in size of conveyor rollers or from other factors. Moreover, glass line speed may be adjusted to a completely different speed, much higher or lower, for production purposes. The clock is adjustable, in keeping with this invention, to synchronize the S mark stepping switch with the glass movement over a wide range of conveyor speeds.

For illustrative purposes, the frequency of input signals to the clock from the tachometer is 5400 per second; an illustrative glass speed is 15" per second which is equal to the total distance of ten S marks spaced 1½" apart—540 input pulses are, therefore, received by the clock for 1½" of glass movement.

The selective resetting means for each clock stage enables selecting either state of each clock stage as the reference state thereby providing means to reset the entire clock to an initial state representing the complement, in binary, of a desired number of input pulses per output pulses, complementary number being 1024. Where it is desired, therefore, to produce an output pulse for every 540 input pulses; that is, an output pulse for each 1½" of glass movement, the clock will be reset to the reference state representing, in binary, the number 484 (1024—540=484). To this end each clock flip-flop stage has two reset terminals O and 1 to which the reset signal may be selectively conveyed by a selector switch 175 to 194. With the selector switch in position O, the flip-flop is set by the reset generator pulse to its alternate state; with the selector switch in its 1 position, the flip-flop is reset to its reference state. Referring to the chart of FIG. 12, the second horizontal line gives the initial states of all flip-flop stages for the complement of 540; the third and sixth to ninth stages are set to their alternate states thereby all stages represent, in binary, the number 484. With the clock reset to the state representing the number 484, the first input pulse shifts the clock to the state representing the number 485, and so on until the clock reaches the state representing 1024 when an output synchronizing and resetting pulse is emitted from the clock tenth stage.

It will be readily understood that the resetting means herein described enables the selection of a clock output frequency between the limits of one to 1024 input pulses per output pulse. Moreover, in the present illustrative case where approximately one output pulse is required per 540 input pulses, the resetting selection provides a fine adjustment of the synchronizing frequency in the order of one part in 500.

I claim as my invention:

1. In apparatus for reading information from a continuously moving record where bits of data are stored at a series of points comprising a set on said record, the combination comprising, detection means for producing a signal denoting either the presence or absence of bits of data at each data point passing said detection means, pulse generating means operated in accord with said record movement for generating a synchronizing pulse as each data point passes said detection means, a multiplicity of output channels comprising a set of output channels corresponding, respectively, to said record data points, and means operated by said synchronizing pulses for feeding successive signals from said detection means to the respective channels coresponding to the data points.

2. In apparatus for reading information from a continuously moving record where bits of data are stored at a series of points comprising a set on said record, the combination comprising, detection means for producing a signal denoting either the presence or absence of bits of data at each data point passing said detection means, pulse generating means operated in accord with said record movement for generating a synchronizing pulse as each data point passes said detection means, a set of output channels corresponding, respectively, to said record data points, means operated by said synchronizing pulses for feeding successive signals from said detection means to the respective channels corresponding to the data points, and means for adjusting the rate of emission of pulses from said pulse generating means to synchronize the latter with said record movement.

3. A system for detecting a moving line as distinguished from a moving spot, comprising three photosensitive elements mounted in alignment so that a passing line simultaneously intercepts light illuminating said elements from a light source behind said line, means responsive to a reduction in illumination of each of said elements producing a dark signal at a terminal electrically connected to the appertaining element, means connecting each one of said terminals and a different one of the other of said terminals for transferring a dark signal produced by a reduction in illumination of one photosensitive element to two of said three terminals, and means for producing an output signal responsive to a dark signal at all three terminals representing a reduction in illumination of at least two of said photosensitive elements due to a passing line.

4. In a photoelectric circuit including three photosensitive type phototubes, means for producing an output signal responsive to a simultaneous reduction in illumination of at least two of said phototubes, comprising: a set of three condensers connected to said phototubes, respectively, so as to be maintained charged with uniform illumination of said phototubes; means for discharging each of said condensers responsive to a reduction in illumination of the connected phototube; a set of three terminals connected, respectively, to said condensers; means including isolating diodes cross connecting each one of said terminals with a different one of the latter so as to drop the potential at two of said terminals responsive to the discharge of one condenser; and an output circuit for producing a signal responsive to a drop in potential at all three terminals representating a reduction in illumination of at least two of said phototubes.

5. In a photoelectric circuit including three photosensitive type phototubes, means for producing an output signal responsive to a simultaneous reduction in illumination of at least two of said phototubes, comprising: a first circuit portion including a resistor and a source of D.C. operating potential in series with each phototube with the three resistors arranged in parallel so as to provide the same first potential at all three junction points between said phototubes and resistors responsive to uniform illumination of said phototubes, and a lower-second potential at the junction point between any one of said phototubes and the series resistor responsive to reduced illumination of said one phototube; a set of three second circuit portion junction points connected to a source of D.C. operating potential; a condenser connected to each one of said first circuit portion junction points and to one of said second circuit portion junction points; means for transferring a drop in potential

from any one of said first circuit portion junction points to a different two of said second circuit portion junction points, and an output circuit for producing a signal responsive to a drop in potential at all three of said second circuit portion junction points representing a reduction in illumination of at least two of said phototubes.

6. In a photoelectric circuit including three photosensitive type phototubes, means for producing an output signal responsive to a simultaneous reduction in illumination of at least two of said phototubes, comprising: a first circuit portion including three rsistors and a source of D.C. operating potential with one of said three resistors in series with each phototube and with the three resistors arranged in parallel so as to provide the same first potential at all three junction points between said phototubes and resistors responsive to uniform illumination of said phototubes, and a lower second potential at the junction point between any one of said phototubes and the series resistor responsive to reduced illumination of said one phototube; a second circuit portion including a set of three parallel resistors with each resistor of said set in series with a resistor of another set of three parallel resistors, a source of D.C. operating potential in series with said sets of resistors to provide a third potential at all three junction points between the resistors of said sets, said third potential being higher than said first and second potentials, a condenser connected between each one of said first circuit portion junction points and one of said second circuit portion junction points so that reduced illumination of any one of said phototubes affects one condenser and produces a dark signal represented by a drop in potential at the second circuit portion junction point connected to the affected condenser; means including isolating diodes cross conecting each one of said second circuit portion junction points with a different one of the latter so as to drop the potential at two of the latter junction points responsive to a single dark signal and an output circuit for producing a signal responsive to a drop in potential at all three second circuit portion junction points representing a reduction in illumination of at least two of said phototubes.

7. In a photoelectric circuit including three photosensitive type phototubes, means for producing an output

signal responsive to a simultaneous reduction in illumination of at least two of said phototubes, comprising: a set of three condensers having terminals connected to said phototubes, respectively, each of said terminals being connected in a circuit so as to be maintained at a fixed potential with uniform illumination of said phototubes and at a lower potential representing a dark signal responsive to a reduction in illumination of the connected phototube; means for charging each of said condensers from a potential source upon a reduction in illumination of the connected phototube producing a dark signal at the condenser terminal; a second set of three terminals connected, respectively, between said condensers and said potential source; means including isolating diodes cross connecting each one of said second set of terminals with a different one of the latter so as to drop the potential at two of said terminals responsive to a dark signal produced by a reduction in illumination of one phototube; and an output circuit for producing a signal responsive to a drop in potential at all three terminals representing a reduction in illumination of at least two of said phototubes.

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