Nov. 3, 1959 T. M. WRIGHT 2,911,045

AUTOMATIC PUNCHING MACHINE

Filed March 10, 1955 7 Sheets-Sheet 1

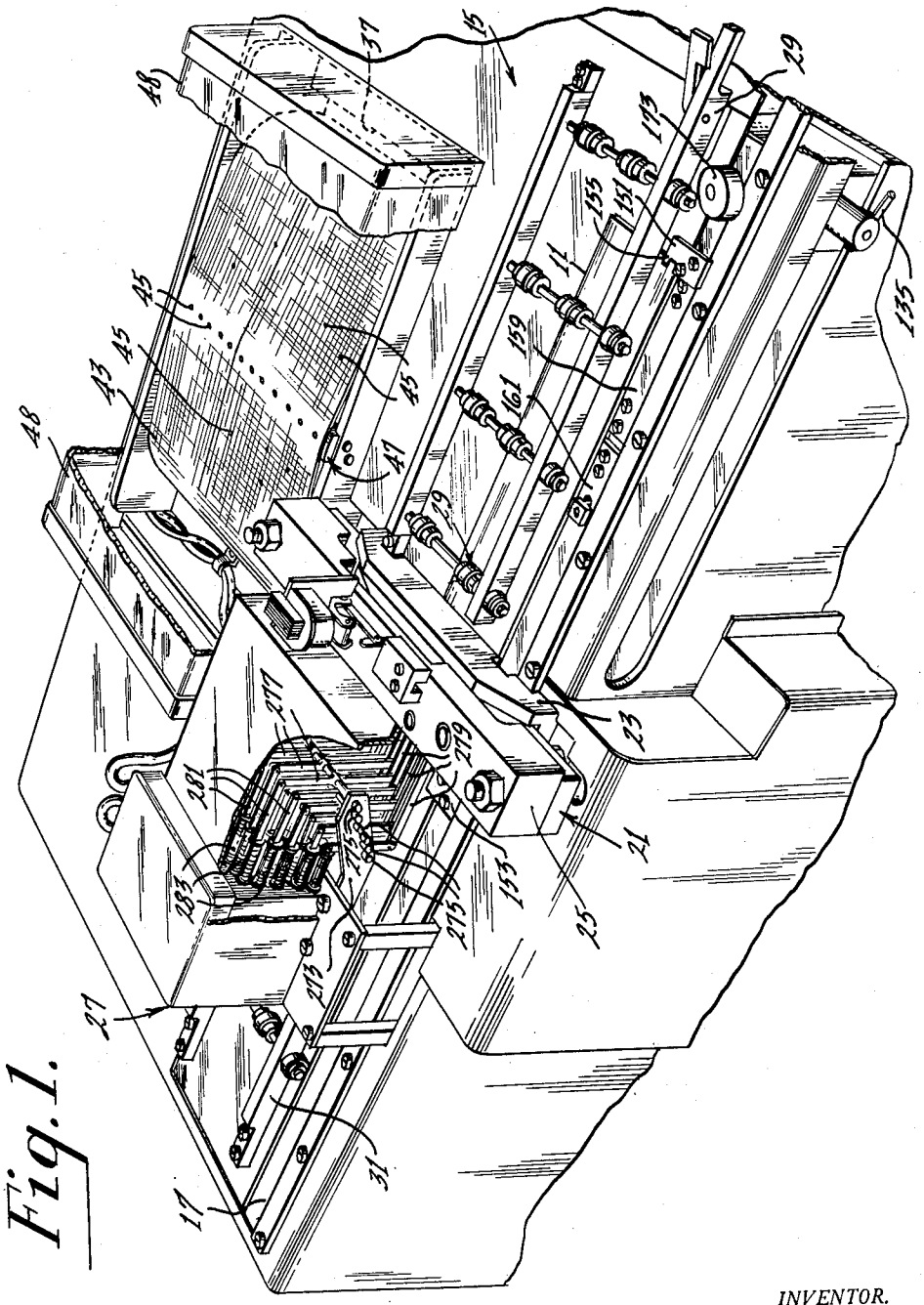


Fig. 1.

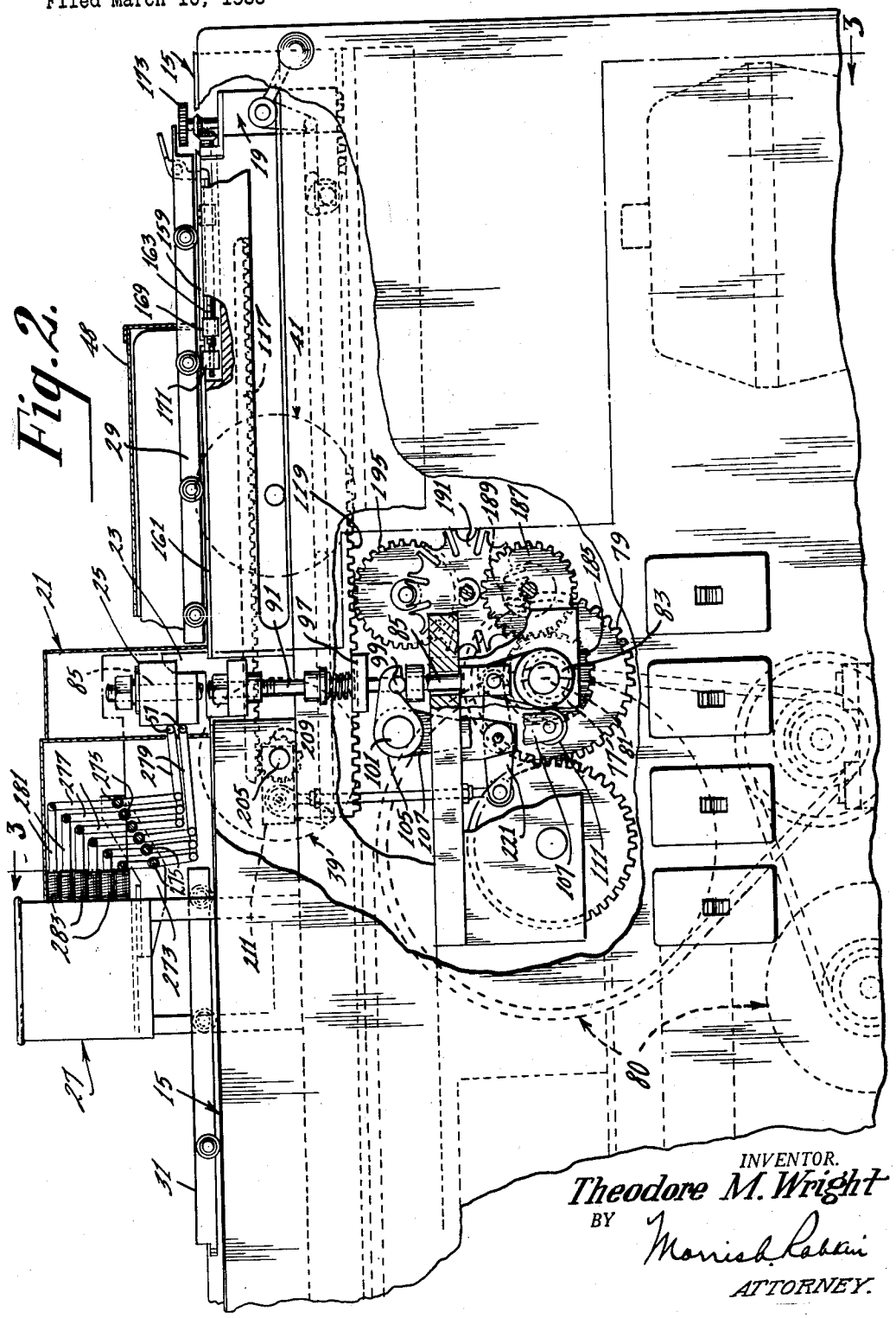
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Nov. 3, 1959 T. M. WRIGHT 2,911,045

AUTOMATIC PUNCHING MACHINE

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Fig. 2.



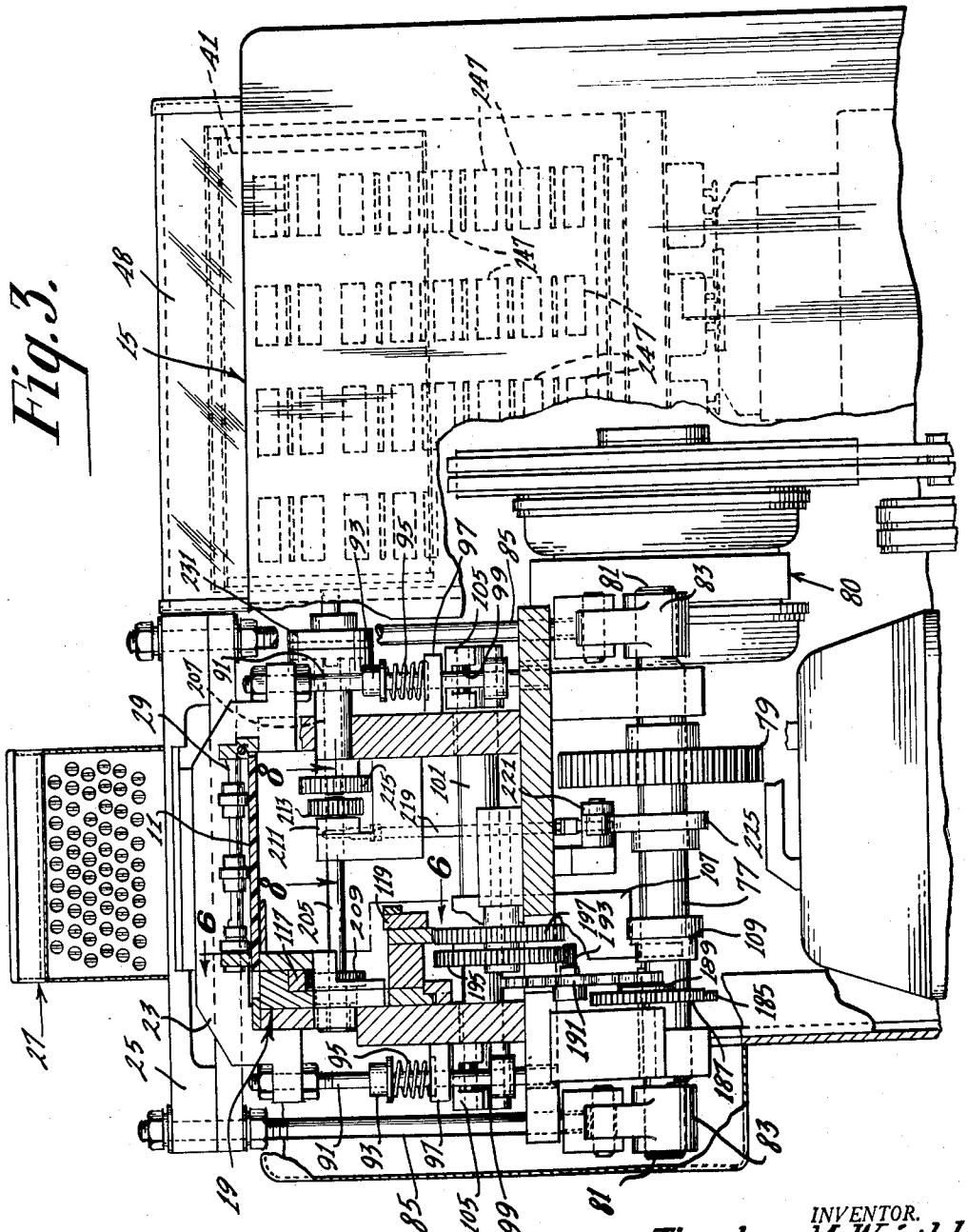
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AUTOMATIC PUNCHING MACHINE

Filed March 10, 1955 7 Sheets-Sheet 3

Fig. 3.



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AUTOMATIC PUNCHING MACHINE

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Fig. 4.

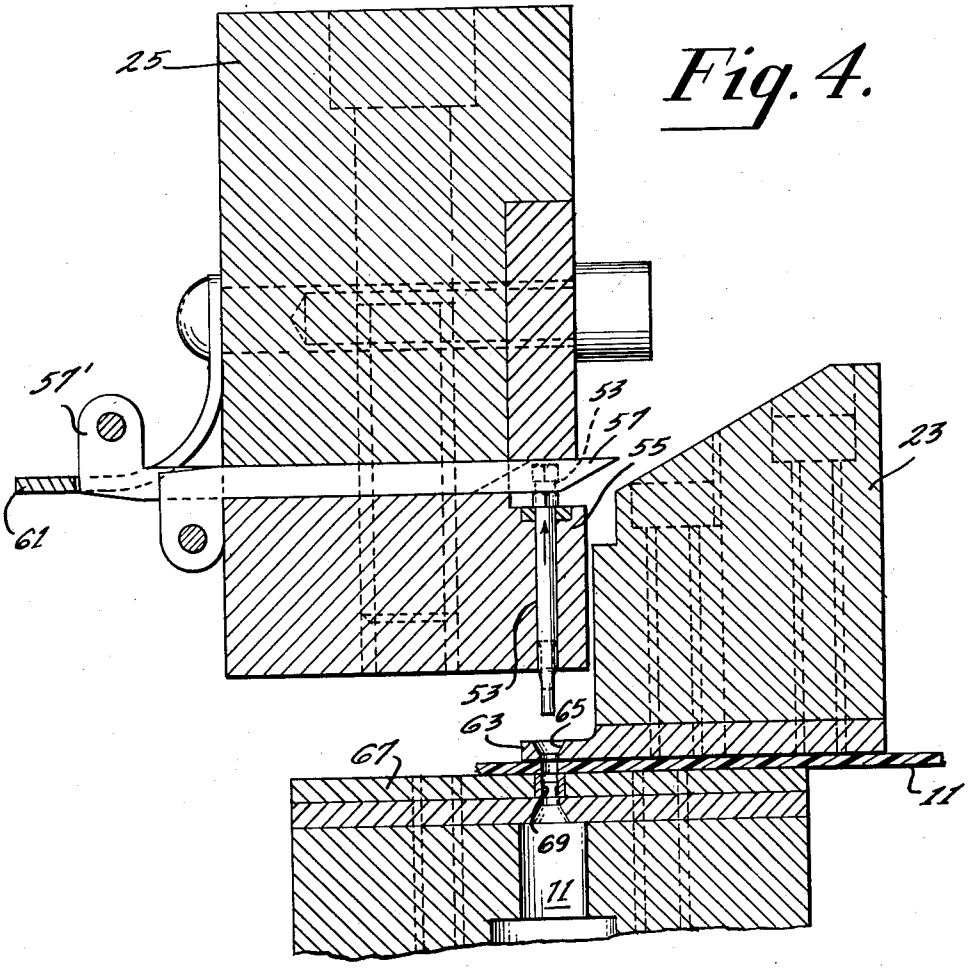
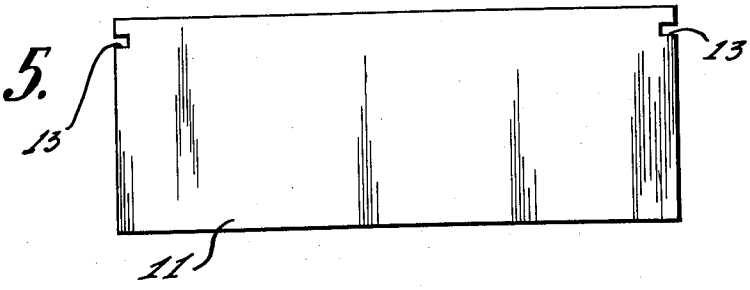


Fig. 5.



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AUTOMATIC PUNCHING MACHINE

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Fig. 6.

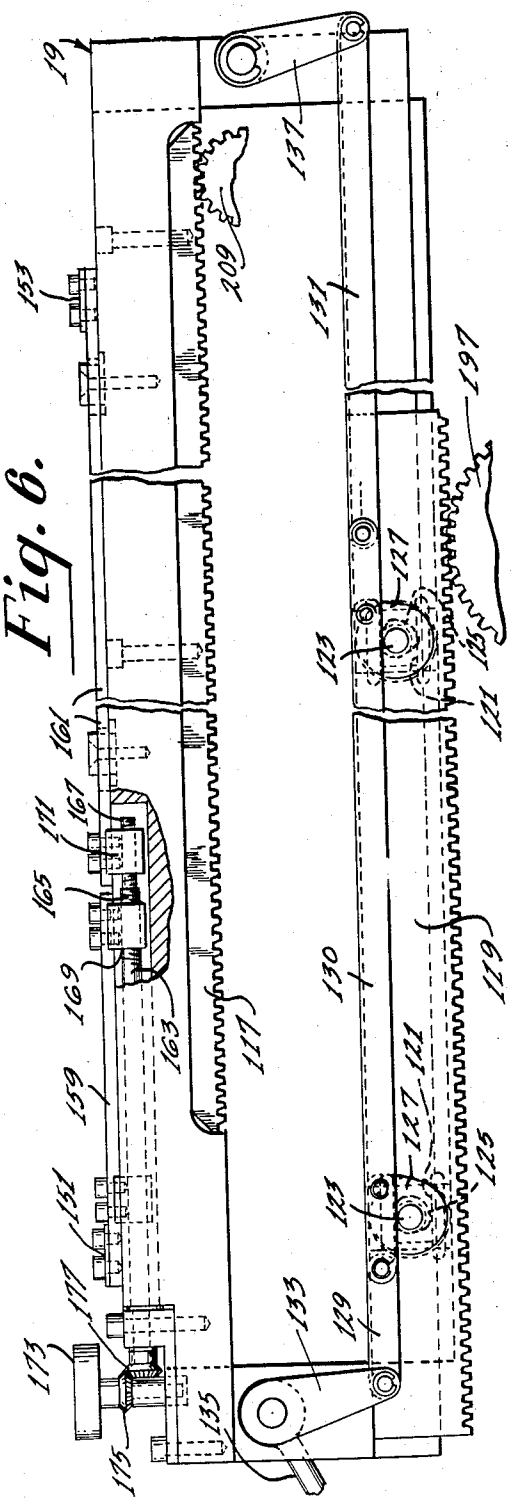
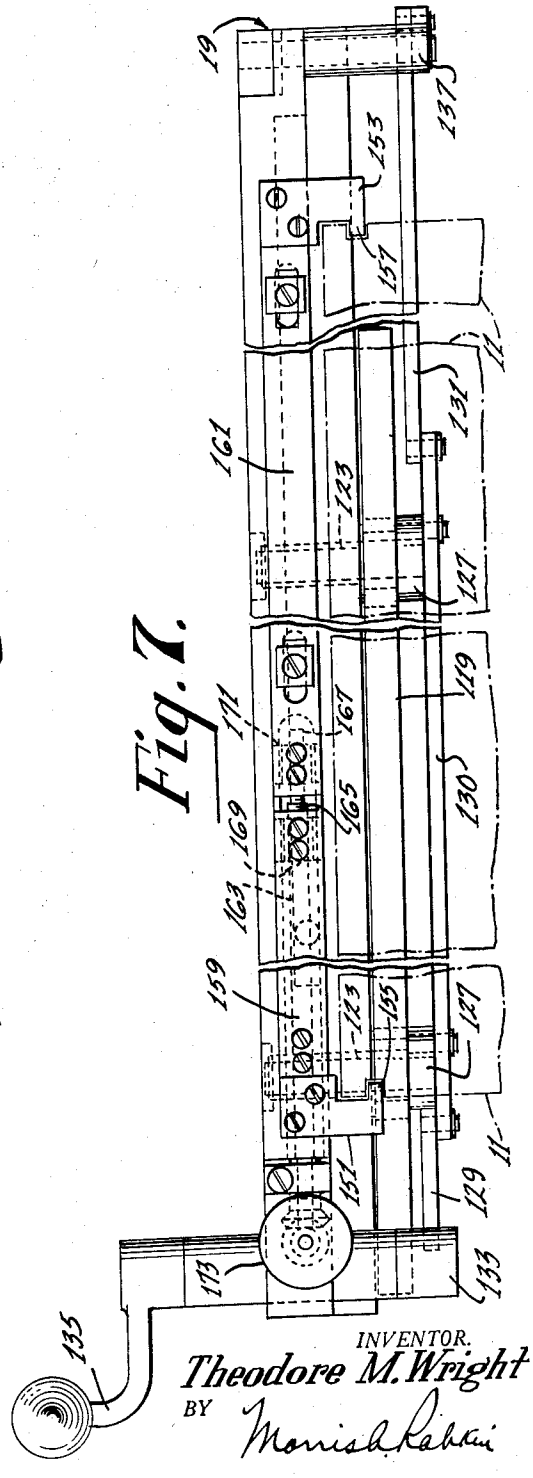


Fig. 7.



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AUTOMATIC PUNCHING MACHINE

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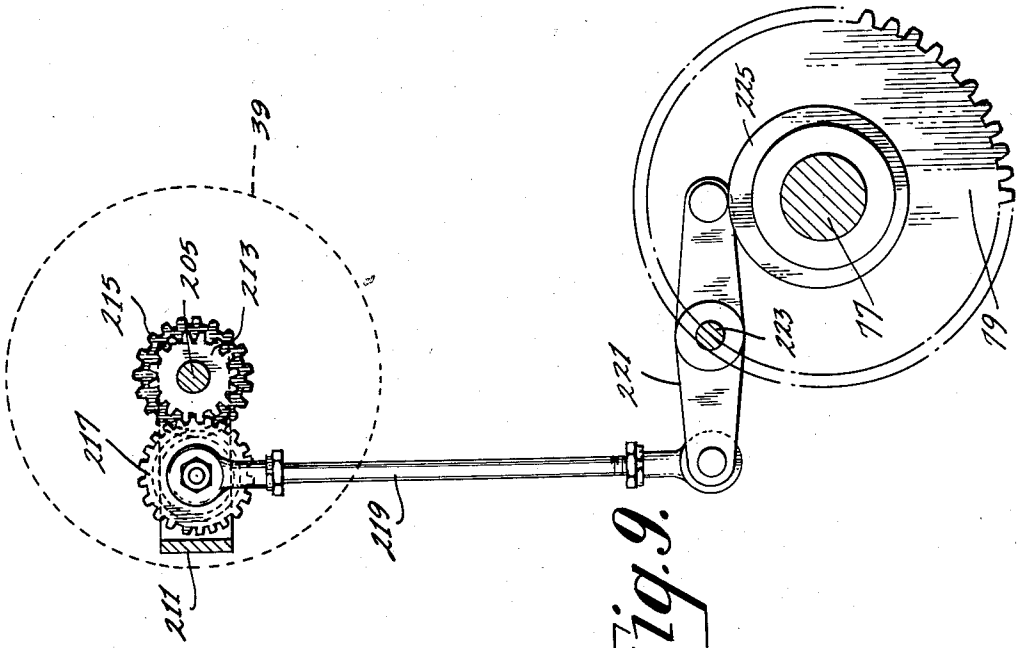


Fig. 9.

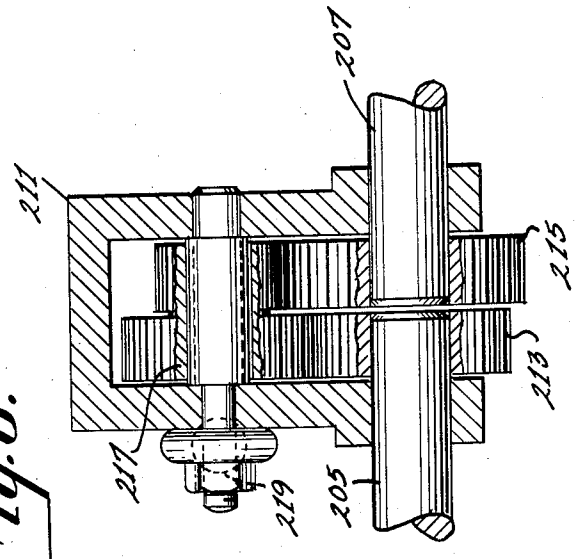


Fig. 8.

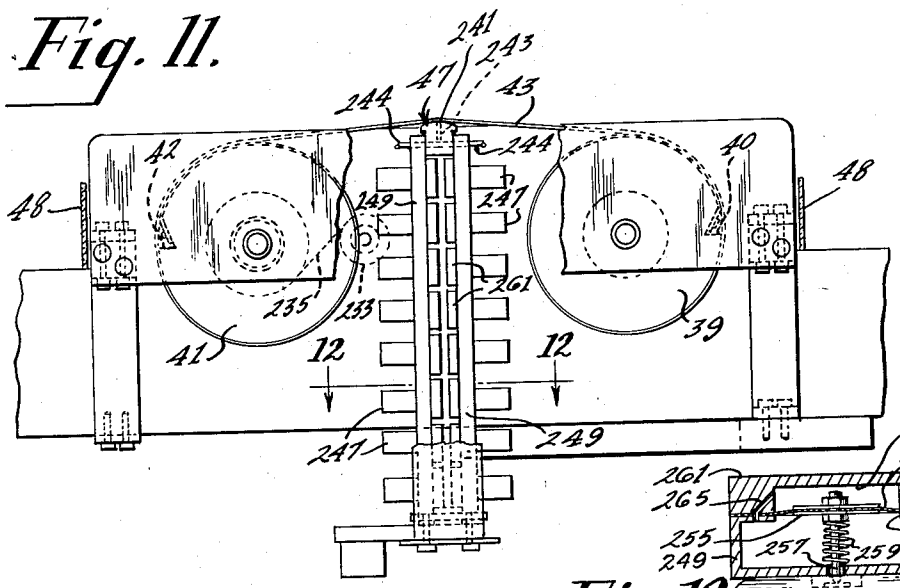
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Nov. 3, 1959 T. M. WRIGHT 2,911,045

AUTOMATIC PUNCHING MACHINE

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Fig. 11.



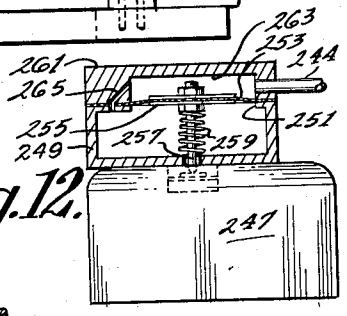


Fig. 12.

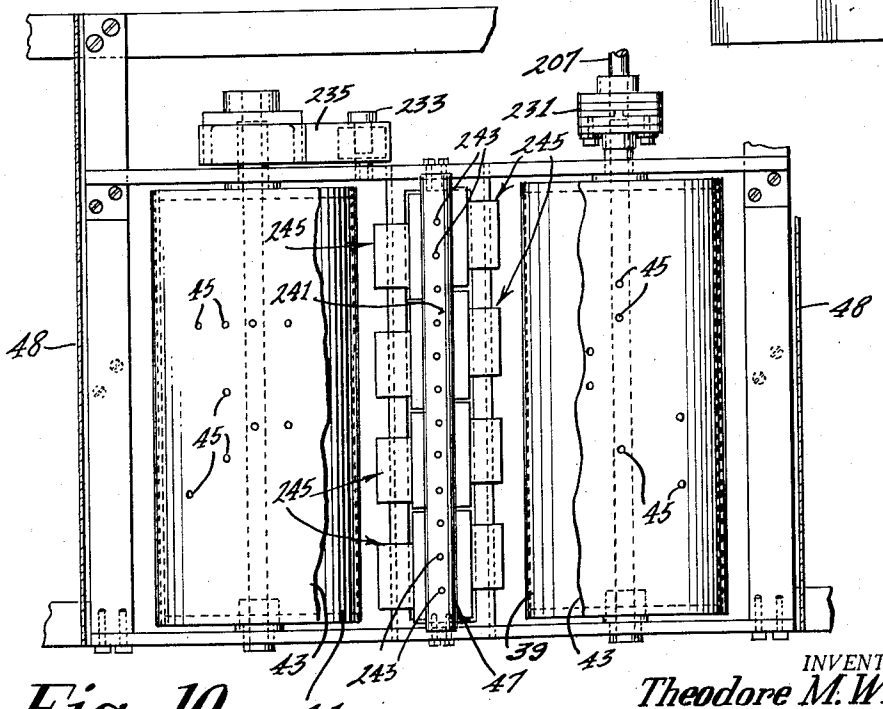


Fig. 10.

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United States Patent Office 2,911,045 Patented Nov. 3, 1959

2,911,045

AUTOMATIC PUNCHING MACHINE

Theodore M. Wright, Camden, N.J., assignor to Radio Corporation of America, a corporation of Delaware

Application March 10, 1955, Serial No. 493,406

7 Claims. (Cl. 164—115)

This invention relates to a programmed punching machine, and more particularly to an automatic machine for punching a pattern of small holes in sheet materials, such as phenolic boards.

In the development of electronic apparatus for mass production, increasing attention is being given to the use of printed circuits which facilitate the use of automatic methods in the production and assembly of such apparatus. One type of printed circuit which is widely used is made up of a thin, conductive layer, such as copper, rigidly fixed to a phenolic board. The circuit is formed by removing a certain portion or portions of the copper layer from the board leaving conductive strips in accordance with a predetermined pattern. Components are fastened to the board by assembling them to the face of the board opposite from the conductive layer and passing the terminals of these components through apertures provided in the board for engagement with the conductive strips.

The principal object of this invention is to provide an improved automatic punching machine for programming and punching small apertures in a sheet of material, such, for example, as a copper coated phenolic board.

Another object of this invention is to provide an improved punching machine for punching holes in a phenolic board in accordance with a pattern laid out on a flexible sheet of material.

A further object of this invention is to provide an improved automatic punching machine wherein perfect registry is always provided between the master pattern and the board being punched.

A still further object of this invention is to provide an improved automatic punching machine wherein both a master pattern and the board being punched are advanced in intermittent steps and wherein the pattern and the board are advanced alternately.

A still further object of this invention is to provide an improved automatic punching machine wherein the mechanism for advancing a board to be punched and the mechanism for advancing a master pattern are directly coupled, and wherein these mechanisms may be selectively disengaged from the machine power source.

A still further object of this invention is to provide an improved automatic punching machine wherein a relatively heavy sheet material may be punched.

In accordance with the present invention a machine is provided for the punching of a sheet material. This machine comprises a punch head carrying a single row of floating punches. The sheet is intermittently stepped beneath the punching head in a direction transversely of the row of punches and the punching head carries the punches toward the sheet after each movement of the sheet. The individual punches do not act to punch a hole in the sheet unless an interference member is positioned above the punch. Interference members are provided for each of the punches in the punching head and are positioned by means of electromagnetic devices

through suitable linkage. The selection of punches is controlled by a master which comprises a pattern corresponding to the hole pattern desired to be punched in the sheet. The master is carried past a sensing mechanism which senses the pattern on the master and selects the proper interference members so that the proper holes are punched in the sheet material by the punching head.

The driving means for the master is directly coupled to the sheet carrier so that perfect registry is always maintained between the master and sheet during either manual or automatic operation of the machine. These elements are coupled by a mechanism which provides for the alternating intermittent movement of the master and sheet resulting in considerably speeded up operation of the machine.

The novel features of the invention as well as additional objects and advantages thereof will be understood more fully from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a perspective view showing the top of a machine in accordance with the present invention;

Figure 2 is a view in front elevation, partially broken away, of the machine of Figure 1;

Figure 3 is a view in side elevation, partially broken away, and partially in section, the section being taken on line 3—3 of Figure 2 looking in the direction of the appended arrows;

Figure 4 is a sectional view of the punching head and associated parts of the machine;

Figure 5 is a view in plan of a printed circuit panel illustrating end notches provided for locating the panel on the machine;

Figure 6 is a view in side elevation and partially in section of the carrier to which the circuit board is attached, this view being taken of the detached part to the left of the line 6—6 of Figure 3 as indicated by the appended arrows;

Figure 7 is a top view of the carrier illustrating the locking fingers for positioning the printed circuit board;

Figure 8 is a fragmentary section of the mechanism for coupling the circuit board carrier and the master driving drum, the section being taken along the line 8—8 of Figure 3 looking in the direction of the appended arrows;

Figure 9 is a detail view, partially broken away, of the control mechanism for the coupling mechanism of Figure 8;

Figure 10 is a top view of the drums for carrying the perforated master and illustrating the reader bar and associated mechanism which cooperates with the perforated master;

Figure 11 is a view in side elevation, partially broken away, illustrating the drums, reader bar and associated mechanism of Figure 10; and

Figure 12 is a detail view, partially in section, of a switch assembly, the section being taken along the line 12—12 of Figure 11 looking in the direction of the appended arrows.

Referring now in more detail to the accompanying drawings, the present invention is embodied in a machine for punching holes in a printed circuit board which is constructed of a copper clad phenolic board. The holes to be punched in the board are positioned at the intersections of a grid pattern which is defined by the spacing between the individual punches of a single row of punches carried in a punching head and the distance which the board is advanced or stepped between each cycle of the punching head. The board is advanced in a direction perpendicular to the row of punches.

The printed circuit board is provided with a means for positively orienting the board with respect to the

punches. Referring to Figure 5, this means comprises a pair of notches 13 which are provided in each end of a printed circuit board 11 and adjacent one edge of the board. These notches 13 are necessarily very accurately indexed with respect to the circuit printed on the board 11, since the holes to be punched in the board must correspond very accurately with the printed circuit.

Referring now to Figures 1, 2 and 3 of the accompanying drawings, the overall structure of the machine is illustrated. A suitable frame structure is provided which is adapted to support the various moving parts of the machine and includes a substantially rectangular table 15. An elongated opening 17 is provided in the table 15 and extends along the front edge of the table for substantially its entire length. A slide carrier 19 for the printed circuit board 11 is located primarily beneath the surface of the table 15 and is mounted in slides for movement across the machine in a manner which will be described. A portion of this carrier extends through the opening 17 and carries the clamping means which engages the notches 13 in the printed circuit board to carry the board across the machine. The board is substantially supported by the table 15 and slides along the table being carried by the carrier 19.

A punching assembly 21 is mounted on the table 15 bridging the area which comprises the path over which the circuit board moves. This assembly includes a stripper 23 which clamps the board 11 against the table 15 during the punching operation and a punching head 25 which carries a single row of floating punches. This row of punches is aligned in a direction perpendicular to the path of movement of the board 11. Also mounted on the table 15 and bridging the path of the circuit board 11 is a bank 27 of solenoids. These solenoids are suitably linked to the punching head in a manner which will be described subsequently.

A pair of hold-down racks 29 and 31 are mounted on the table 15 on either side of the punching assembly. Each of these racks comprises a frame with rollers which are positioned at just sufficient height above the surface of table 15 to permit a circuit board to pass beneath it and hence maintain the board flat against the table surface throughout the punching operation. One of these racks 29 is hinged so that it may be raised out of the way for the purpose of placing in or removing a circuit board from the carrier 19.

A relatively large rectangular opening 37 is provided in the table 15 toward the rear of the table and permits access to a pair of rotating drums 39 and 41 which are positioned at either end of this opening 37. These drums are provided for carrying a pattern or master 43 which controls the operation of the punches. The master is made up of a strip of impregnated glass cloth having holes 45 arranged in a pattern which is identical to the arrangement of holes to be punched in the circuit board 11. The holes 45 are positioned at intersections of a grid which comprise columns extending longitudinally of the strip and transverse rows extending perpendicular to the columns and spaced apart a distance equal to the amount the master is stepped for each punching cycle. For convenience, the scale of this master may differ from the scale of the circuit board. A reader bar 47 is mounted within the opening 37 between the two drums 39 and 41. A transparent cover 48 is provided for the opening 37 to protect the exposed mechanism yet permits visual observation.

The reader bar 47 comprises a single row of openings which are aligned in a direction perpendicular to the direction of motion of the master over the reader bar. These openings correspond to the punches in the punching head. Each of the openings in the reader bar is connected to a chamber associated with an individual pressure operated microswitch which is normally maintained in the open position. The chamber is maintained under vacuum. When the machine is operating, the circuit board 11 passes under the punching head 25 in synchronism with the passing of the master 43 over the reader bar 47. When a hole 45 in the master is positioned over an opening in the reader bar 47, the vacuum in the associated chamber is broken and the associated switch is caused to close. The switch causes one of the electromagnetic devices to be energized causing the punch corresponding to the particular hole 45 in the master to punch a hole in the circuit board 11.

Referring now to Figure 4 a sectional view of the punching assembly 21 is illustrated. The punching head 25 carries a plurality of punches 53 aligned in a single row which extends perpendicular to the plane of the drawing in Figure 4. These punches are substantially cylindrical in shape having a portion of smaller cross section at the punching tip and having an enlarged head at the upper end. The punches are carried in a lower flange 55 which extends laterally from the punching head 25. This flange is provided with vertical cylindrical apertures within which the punches move freely and are supported within the apertures by the enlarged heads. An interference bar 57 is provided for each of the punches 53. These bars are made up of rigid metallic strips which extend laterally through the punching head in a direction perpendicular to the row of punches. The bars move freely in slots provided in the punching head and, when fully inserted into these slots, the ends of the interference bars extend over the upper end surfaces of the enlarged heads of the punches 53. In this position of an interference bar 57, a punch 53 is restricted from vertical movement; hence when the punching head 25 descends toward the circuit board the punch will be forced through the circuit board. If, however, an interference bar 57′ is partially withdrawn from the punching head 25, the punch corresponding to that interference bar will be permitted to move upwardly a limited distance. This distance is sufficient so that, as the punching head descends, when a punch engages the upper surface of a circuit board 11 it will merely ride upward relative to the punching head during the continued downward movement of the punching head and no hole will be punched in the circuit board. A stop bar 61 is provided to limit the amount by which the interference bar may be withdrawn from the punching head. The mechanism for operating these interference bars will be described subsequently.

The stripper 23 is provided with a laterally extending flange 63 which extends beneath the punching head 25. This flange is provided to hold the circuit board 11 tightly to the table 15 in the immediate area of the punches 53 and is provided with a row of apertures 65 permitting the punches 53 to pass downwardly through the flange. The table 15 and the area immediately beneath the punching head comprises a die plate 67 having a row of die apertures 69 corresponding to the punches 53. An enlarged chamber 71 beneath the die apertures may be associated with a suction system whereby the punched out portions of the circuit boards may be drawn into a refuse container.

Referring now especially to Figures 2 and 3, the operating mechanism for the punching assembly 21 comprises crank shaft 77 which is supported in bearings adjacent either end of the shaft and is horizontally disposed beneath the punching head 25. The crank shaft 77 is driven through a gear 79 which is rigidly fixed to the shaft. The gear 79 is in turn coupled to a suitable power source and clutch arrangement 80. These portions 80 of the machine are not described in detail since such description is not deemed essential to the disclosure of the present invention. Each end of the shaft is provided with an eccentric portion 81 which acts as a crank. These cranks are phased to operate in unison. Each of these eccentric portions 81 is enclosed by an eccentric housing 83 which is pivotally attached to the lower end of a rod 85. Each of the rods 85 is rigidly fixed at its upper end to one end of the punching head 25. The rods 85 are

slidably supported within the machine frame to permit only a reciprocating movement in a vertical direction. The shaft **77** then drives the punching head **25** through the eccentrics **81**.

A pair of rods **91** are rigidly attached to either end of the stripper **23** and extend downwardly in a vertical direction just inside of the rods **85**. These rods are also slidably supported in the machine frame to permit only a vertical reciprocating motion. Each of the rods **91** is provided with an annular flange or collar **93** at a point intermediate its ends. Each of these flanges **93** provides an upper bearing surface for a coil spring **95** whose lower bearing surface is a portion of the machine frame **97**. This coil spring **95** biases the rods **91**, and therefore the stripper **23**, toward its upper limit, that is, to a position where the stripper will not clamp a circuit board **11** against the table **15**. A coupling member **99** is attached adjacent the lower end of each of the rods **91** to provide a fulcrum by means of which a reciprocating motion is imparted to the rods **91**. A stripper shaft **101** is rotatably mounted in the machine frame and extends parallel to the crank shaft **77**. A pressure lever **105** is rigidly fixed to each end of the stripper shaft **101** and each of these pressure levers **105** engages a coupling member **99** which is attached to one of the rods **91**. A cam lever **107** is rigidly fixed to the stripper shaft **101** at a point intermediate the ends of the stripper shaft. This lever **107** is attached at one end to the shaft **101** and its other end extends downwardly to a point adjacent the crank shaft **77**. A cam **109** is fixed to the crank shaft **77** and engages a cam follower **111** which is carried by the cam lever **107**. The combination of the cam lever **107**, stripper shaft **101**, and pressure lever **105**, form a bell crank arrangement through which the rods **91** are driven downwardly by means of the cam **109**. Hence the stripper **23** is caused to clamp a circuit board **11** against the table **15** by the positive action of the cam **109** and its associated mechanism. At the end of the punching cycle, after the punches have been withdrawn from the board, the cam **109** permits the stripper to be raised from clamping engagement and this upward force is provided by the coil springs **95**.

Referring now to Figures 6 and 7 the carrier **19** comprises a frame having mounted thereon a pair of horizontally extending racks **117** and **119** which are disposed in parallel relation with each other one above the other and, at its upper surface, a clamping mechanism for rigidly clamping a circuit board **11** to the carrier **19**. The upper rack **117** is rigidly fixed to the carrier frame and is provided for driving the master drum **39** through a coupling mechanism which will be described subsequently. The lower rack **119** is mounted to be movable in a vertical direction relative to the carrier frame. This motion is provided so that the rack **119**, and hence the carrier **19** may be selectively disengaged from the carrier driving mechanism which will be described.

The rack **119** is provided with a pair of apertures **121** having opposing upper and lower edge surfaces which are accurately spaced relative to each other. Two shafts **123**, each having a cam portion **125** intermediate its ends, are rotatably mounted at spaced positions on the carrier frame and extend laterally from the frame in a direction perpendicular to the rack **119**. The rack apertures **121** are spaced to correspond with the spacing of the shafts **123** and will receive the cam portions **125** of these shafts. The cam portions **125** are designed to provide a crank action with respect to the axis of rotation of the shafts **123**. As the cams **125** are rotated, the distance between parallel tangents to the cam surfaces remains constant. Therefore when the shafts **123** are oscillated through a given angle, the rack **119** will be caused to reciprocate in a vertical direction.

A crank **127** is fixed to the free end of each of the shafts **123**. These cranks are linked together and operated by appropriate linkage **129**, **130** and **131**. The two cranks **127** are connected by the link **130** and rotate together. Link **129** is connected at one end to the link **130** and at its other end to a crank **133**. The crank **133** is rigidly attached to and manually operated by a lever **135**. The link **131** is connected at one end to the link **130** and at its other end is supported by a crank **137** which is pivotally attached to the carrier frame. This crank **137** extends in a substantially vertical direction. When the carrier **19** is engaged with its driving mechanism, the crank **137** is swung to a position toward the leading end (right hand end in Figures 6 and 7) of the carrier **19**. In the event that the means for normally stopping the operation of the machine should fail, when the carrier reaches the limit of its travel, the crank **137** moves into engagement with a member attached to the machine frame causing the crank **137** and associated linkage to move in the opposite direction thereby disengaging the rack **119** from the carrier driving mechanism and preventing damage to the machine.

The mechanism for clamping a circuit board **11** to the carrier **19** is mounted on the top surface of the carrier. A pair of jaws **151** and **153** are provided adjacent either end of the carrier **19**. Fingers **155** and **157** are provided respectively on the jaws **151** and **153** and extend toward each other to engage the notches **13** provided at either end of the printed board **11**. Each of the jaws **151** and **153** is attached to the end of an arm **159** and **161**. These arms are aligned in a longitudinal direction and the ends of the arms opposite from the jaws are adjacent each other in a near abutting relationship. A shaft **163** extends from one end of the carrier **19** to the point where the butting ends of the arms **159** and **161** are adjacent each other. This end of the shaft is provided with two threaded portions **165** and **167** which are adjacent each other and which have reverse threads provided thereon. A pair of blocks **169** and **171** are mounted on the threaded portions **165** and **167** of the shaft **163**. The blocks **169** and **171** are attached respectively to the adjacent ends of the arms **159** and **161**. When the shaft **163** is rotated the arms **159** and **161** are moved either toward each other or away from each other and a corresponding movement is imparted to the jaws **151** and **153**. A knob **173** is coupled to the shaft **163** by means of bevel gears **165** and **167** and provides the means for manually opening and closing the jaws **151** and **153** for the purpose of locking or releasing a circuit board **11** from the carrier **19**.

Referring now especially to Figures 2 and 3, the driving mechanism for the carrier **19** includes a gear **185** which is rigidly mounted on the crank shaft **77** and which meshes with a gear **187**. The gear **187** carries a Geneva drive **189** which engages a Geneva plate **191** to provide an intermittent motion for the carrier **19**. The Geneva plate **191** carries a pinion **193** which meshes with one of a pair of gears **195** and **197** which rotate together by means of a shear connection. The shear connection will, of course, fracture should the machine be overloaded. The gear **197** engages the rack **119** of the carrier **19**.

The driving mechanism for the drum **39** comprises a pair of aligned shafts **205** and **207** which are coupled together by a phase shifting mechanism which will be described. The shaft **207** is directly coupled to the drum **39**. The shaft **205** has a gear **209** rigidly fixed to one end which meshes with the rack **117** of the carrier **19**.

Referring now to Figures 8 and 9, the phase shifting mechanism comprises a U-shaped housing **211** which is pivotally mounted about the axis of rotation of the shafts **205** and **207**. The adjacent ends of these shifts extend into the housing **211** and carry rigidly fixed gears **213** and **215** respectively on the shafts **205** and **207**. The member **217** having two integral gear portions is rotatably mounted within the housing **211** about an axis parallel with the axes of the shafts **205** and **207**. The gear portions of the member **217** mesh with the two gears **213** and **215** to provide a constant coupling between the shafts **205** and **207** and hence between the carrier **19** and the drum **39**.

The mechanism just described is an oscillating plane-

tary. The mechanism is oscillated about the axes of the shafts **205** and **207** by means of a link arm **219** which is attached at one end to the housing **211** at a point removed from the axis of the shaft **205** and is attached at its other end to one end of a rocker arm **221** which is rotatably mounted on a fixed shaft **223**. A differential cam **225** is rigidly attached to the crank shaft **77** and is engaged by a cam follower which is attached to the other end of the rocker arm **221**. By means of the differential cam **225**, the oscillating planetary is caused to oscillate in timed relation with the intermittent motion of the carrier **19**. When the carrier **19** is advanced and the shaft **205** is consequently rotated through a fixed angle, the housing **211** is simultaneously rotated through a fixed angle about its mounting axis in a manner such that no rotation is imparted to the gear **215** and consequently to the shaft **207** and the drum **39**. When the carrier motion is stopped and the shaft **205** has ceased to rotate, the housing **211** is rotated in a reverse direction to return to its original position thereby imparting rotation to the shaft **207**. The net effect of this mechanism then is to delay the driving of the drum **39** by the carrier **19** without effecting the angle through which the drum is rotated.

Referring now to Figures **10** and **11** the drums **39** and **41** are rotatably mounted parallel each other and are provided respectively with paper anchoring slots **40** and **42**. The drum **39** is directly connected to the shaft **207** through a flange coupling **231** and is the driving drum for the master **43**. The drum **41** is the storage drum for the master **43**. In order to provide tension on the master **43** when it is attached to the drums, a "Negator" motor **233** is coupled to the drum **41**. This Negator motor comprises a coiled spring **235** which is coiled about an axis parallel to the axis of rotation of the drum **41** and one end of which is secured to an axial projection of the drum **41**. As the master is drawn from the storage drum **41** by the driving drum **39** the spring will wrap around the axial projection of the drum **41** uncoiling from its original position. The Negator motor is designed so that a back tension applied by the spring as it uncoils is substantially constant within the operating limits of the motor. This Negator motor then provides a constant tension on the master as it is being drawn from the storage drum **41** and also provides for the rewinding of the master on the storage drum after a machine cycle has been completed and it is desired to return the carrier and master to their starting positions.

The reader bar **47** is disposed between the drums **39** and **41** and comprises an elongated member having a smooth upper surface **241** which has a rounded sectional contour. The surface **241** is provided with a single row of apertures **243** which extend into the reader bar **47** and provide individual chambers within the reader bar. Means are provided for connecting an air conduit **244** to each of the individual chambers provided in the reader bar **47**. A plurality of banks **245** of pressure operated switches **247** are attached to the reader bar **47** and extend downwardly from the reader bar. Each bank **245** comprises an elongated vertically extending tubular member **249** which is rectangular in cross section. A row of spaced openings **251** are provided along one surface of the tubular member **249**. One of these openings **251** is illustrated in Figure **12**. These openings **251** are each closed by a diaphragm **253** having a rigid disc member **255** secured to the diaphragm and disposed centrally of the aperture **251**. A pin **257** is rigidly fixed to the disc member **253** and extends perpendicularly from the disc member across the tubular member **249** and through a small opening in the side of the tubular member opposite from the diaphragm opening **251**. The switches **247** are mounted on the tubular member **251** and are actuated by the pins **257**. A helical compression spring **259** is disposed within the tubular member **249** around each of the pins **257** and biases the disc member **255** to hold the pin out of engagement with the switch **247**.

Each of the diaphragm openings **251** in the tubular member **249** is covered by a housing **261** to provide a closed chamber **263** at the outer surface of each of the diaphragms **253**. Each of these chambers is connected, by means of previously mentioned air conduits **244** to an individual chamber associated with one of the apertures **243** in the reader bar **47**. A bleeder passage **265** is provided between each of the chambers **263** and the interior of the tubular member **249**. When the machine is operating, a vacuum is applied to the chamber of the tubular member **249** and a negative pressure is maintained within a chamber **263** when its corresponding aperture **243** in the reader bar **247** is sealed off by the master **43**. When one of the holes **45** in the master **43** is positioned over an aperture **243** in the reader bar **47**, atmospheric pressure is admitted to the corresponding chamber **263** and the differential pressure acting on the diaphragm **253** between the chamber **263** and the chamber within the tubular member **249** is sufficient to overcome the force of the spring **259** and to move the pin **257** to actuate the switch **247**. The bleeder passage **265** is sufficiently small so that the vacuum within the tubular member is not significantly reduced. When the master is again moved across the reader bar **47** so that the chamber **263** is again sealed off from the atmosphere, the vacuum is restored to the chamber **263** by means of the bleed **265** to again equalize the pressures on both sides of the diaphragm **253** permitting the spring **259** to return the pin **257** to its original position.

Referring again to Figures 2 and 3 of the mechanism for operating the interference bars **57** will now be described. This mechanism includes a bank of solenoids **27** which is mounted above the path of the circuit board **11**. A solenoid is provided for each of the interference bars and these solenoids are disposed so that the movable member moves in a direction substantially parallel to the movement of the interference bars **57**. A pair of brackets **273** support a plurality of shafts **275**. Each of these shafts supports a plurality of rocker arms **277** mounted for rotation with respect to the shaft. The rocker arms **277** extend in a substantially vertical direction and each of the rocker arms is connected at its lower end to one of the interference bars **57** by means of a suitable link **279**. Each of the rocker arms **277** is connected at its upper end to the movable member of one of the solenoids **271** by means of a suitable link **281**. A compression spring **283** is associated with each of the links **281** and acts to bias the links **281**, and consequently the plungers of the solenoids **271**, toward the right (referring to Figure 2). Through the rocker arms **277**, the interference bars **57** are biased toward the left or to the position where the punches will not be actuated by the punching head. Each of the solenoids **271** is electrically connected to one of the switches **247**. When a switch **247** is closed, its corresponding solenoid **271** is actuated to place an interference bar **57** in position over its corresponding punch **55** whereby a hole is punched in a circuit board.

The machine which has been described above is designed for a circuit board **11** having a standard length and having indexing notches **13** of standard size placed a standard distance from the edge of the board. The circuit board may be of any width within the limit which is determined by the number of punches provided in the punching head.

The glass cloth master **43** is punched with holes which are arranged in the pattern which is to be punched in the circuit board. The master is attached to the drums **39** and **41** in the paper anchoring slots **40** and **42**. The machine is set up so that when the carrier **19** is set in its starting position (the position illustrated in Figure 2), the angular position of the anchoring slot **40** in relation to the drum **39** is fixed so that the leading edge of the master **43** extends a fixed distance past the reader bar **47** when it is attached to the drums. This is necessary so that the hole pattern provided on the master will always

begin a fixed distance from the leading edge of the master.

When the machine is started, the carrier **19** will advance the circuit board **11** in intermittent, equally spaced steps beneath the punching head **29**. During each advancement of the carrier **19** the drum **39** is prevented from rotating by means of the oscillating planetary mechanism. After each advancement, the carrier stops and the drum **39** is advanced by means of the oscillating planetary drawing the master **43** over the reader bar **47** a predetermined distance. Through this arrangement, the advancement of the hole pattern on the master across the reader bar is timed to be approximately one half cycle ahead of the advancement of the circuit board. Hence when the carrier is stopped during the punching of a transverse row A of apertures in a circuit board, the drum **39** advances the master so that a transverse row B of apertures **45** in the master is positioned over the reader bar. As soon as this occurs the solenoids corresponding to these apertures will be energized through the described vacuum switching mechanism and will attempt to set up the corresponding interference bars **57** in the punching head **25**. These interference bars **57** may not move in over the punches however until the punching head **25** moves upwardly permitting the punches to drop to their normal rest positions on the flange **55**. As the punching head moves upwardly the master **43** is maintained in this position over the reader bar **47** while the circuit board is advanced beneath the punching head. As the punching head descends to punch the row B of apertures in the circuit board **11** the drum **39** again advances the master **43** to position a tranverse row C of apertures in the master over the reader bar. The advantage of this alternating movement of the master **43** and the circuit board **11** is that considerably more punches per unit of time can be made without increasing the speed of the operating mechanism. If these two members were advanced simultaneously a delay time would be required to permit interference bars to be set up in the punching head before the punch head could be moved downwardly to punch the circuit board.

It will be noted that all of the moving parts of the machine are driven through the crank shaft **77**. The cam **109** is attached to the crank shaft **77** in a fixed angular relation with the eccentric portions **81**. The timing is fixed so that the cam **109** will cause the stripper to clamp a circuit board **11** tightly against a die plate **67** immediately before the punches **53** are forced through the circuit board by the eccentrics **81**. By the same token the stripper **23** is maintained in this position until the punches **53** have been completely withdrawn from the circuit board **11** to prevent any upward movement of the circuit board. As soon as the punches have been withdrawn from the board the stripper pressure is released permitting the board to be advanced for the next punching cycle. As previously described, the advancing mechanism for the carrier is directly driven from the crank shaft **77** as is the cam **225** which controls the timing for the coupling mechanism between the carrier **19** and the drum **39**. As a result of this arrangement it is a simple matter to adjust and maintain the timing between various components of the machine.

What is claimed is:

1. In a machine for producing a punched panel under control of a master, means for sensing said master, means comprising a plurality of punches for punching said panel, means for intermittently stepping said panel past said punches, means for intermittently stepping said master past said sensing means, means directly coupling said panel stepping means and said master stepping means in positive geared relation, said coupling means providing for varying in a predetermined manner the timed relationship of the stepping of said master with respect to the stepping of said panel, means for selectively engaging and disengaging said coupled stepping means from a drive source without disturbing said timed relationship, means under control of said sensing means for selecting individual ones of said punches, and means for actuating said selected punches to punch said panel to correspond with the pattern of said master.

2. In a machine for punching a panel under control of a master having a plurality of columns of perforations, a plurality of punches, each punch thereof being correlated with a column of said perforated master and each punch being adapted to punch in any one of a plurality of positions in a master column, a plurality of pressure responsive control elements adapted to cooperate with said master, a carrier for said panel, means comprising intermittent drive gearing for driving said carrier intermittently past said plurality of punches, means for selectively disengaging said carrier from said intermittent drive gearing, means for carrying said perforated master past said pressure responsive control elements, means directly coupling said master carrying means and said carrier in definite phase relationship, a plurality of switches actuated by said control elements, a plurality of electromagnetic devices energized by said switches, and means actuated by said electromagnetic devices for selecting said punches so that said panel is punched to correspond with said master.

3. In a machine for punching a panel in accordance with a master, punching means comprising a plurality of spaced punches, a punch support member, means for driving said punches by said member, a slide for supporting said panel, said slide comprising a pair of racks, an intermittent drive mechanism associated with one of said racks for stepping said slide beneath said punch driving means, means for selectively disengaging said one rack from said intermittent drive mechanism, a sensing means, means for carrying said master over said sensing means, said carrying means comprising a pair of drums, means directly coupling one of said drums and said other rack whereby said master and said slide are always positively indexed with respect to each other, and means associated with said other drum for maintaining a constant tension on said master between said drums.

4. In a machine for punching a panel under control of a perforated master, said master having holes aligned in columns and spaced at predetermined intervals in said columns, a line of punches each being correlated with a column of said perforated master and each being adapted to punch in any one of a plurality of positions in a master column, a carrier for supporting said panel for carrying said panel beneath said line of punches, means comprising intermittent drive gearing for feeding said carrier intermittently beneath said line of punches, a rack associated with said carrier adapted to mesh with said intermittent drive gearing, means for disengaging said rack from said intermittent drive gearing, a plurality of solenoids each for controlling one of said punches, a plurality of switches each for actuating one of said solenoids, a plurality of switch control elements for actuating said switches, said switch control elements being responsive to differential pressure, means whereby each switch control element is controlled by one column of said perforated master, means for carrying said master past said last mentioned means whereby each switch control element is controlled, and means directly coupling said carrier and said master carrying means whereby said master and said panel are always in perfect registry with each other.

5. In a machine for punching a panel under control of a flexible perforated master, said master having holes aligned in columns and spaced at predetermined intervals in said columns, a line of punches each being correlated with a column of said perforated master and each being adapted to punch in any one of a plurality of positions in a master column, a carrier for supporting said panel and for carrying said panel beneath said line of punches, means comprising intermittent drive gearing

for feeding said carrier intermittently beneath said line of punches, a rack associated with said carrier adapted to mesh with said intermittent drive gearing, means for selectively disengaging said rack from said intermittent drive gearing whereby said carrier may be positioned manually, sensing means adapted to cooperate with said master, means responsive to said sensing means for setting up individual ones of said punches, means comprising a driving drum and a storage drum for feeding said master past said sensing means, means directly coupling said carrier and said driving drum whereby said master and said panel are always in perfect registry with each other, and a spring motor associated with said storage drum, said motor providing constant tension on said master as it is drawn from said storage drum to said driving drum.

6. In a machine for punching a panel under the control of a perforated master, said master having holes aligned in columns and spaced at predetermined intervals in said columns, means for advancing said panel in intermittent steps, means directly coupled to and in timed relation with said panel advancing means for advancing said master, a punching head mounted over the path of said panel, a plurality of floating punches carried in said punching head, each of said punches being correlated with a column of said perforated master and each being adapted to punch in any one of a plurality of positions in a master column, means under control of said perforated master for selecting individual ones of said punches, a die plate mounted beneath said punching head, a stripper for clamping said panel against said die plate, a crank shaft, said panel advancing means being directly driven from said shaft, means for selectively engaging and disengaging said panel advancing means from said shaft without disturbing said timed relationship between said panel and said master, cam means associated with said shaft for drawing said stripper against said die plate, and crank means associated with said shaft for driving said punching head toward said die plate, said stripper being maintained in clamping relationship with said die plate throughout the cycle of said punching head.

7. In a machine for punching a printed circuit board in accordance with a perforated master, sensing means including a reader bar having a row of spaced passages terminating at its upper surface, punching means including a plurality of spaced punches aligned in a row over a punching die, a single mechanically driven member for driving all of said punches, an interference bar for each of said punches adapted to be positioned between the same and said member whereby the latter may drive said punches through the medium of said interference bars, a control solenoid for each interference bar adapted to position the bar between its punch and said member only during the time said solenoid is energized, a pressure operated switch for each solenoid, a housing associated with each switch comprising two chambers separated by a diaphragm, each of said housings being provided with a bleeder passage between said chambers, actuating means for said switches mounted on said diaphragms, one of said chambers in each of said housings adapted to be placed under a vacuum, means connecting one of said reader bar passages to said other chamber of each of said housings, means for biasing each of said diaphrams toward said chamber connected to said reader bar, means for carrying said perforated master over said reader bar in intermittent steps, means for carrying said printed circuit board beneath said punch driving member in intermittent steps, means directly coupling together said carrying means, said coupling means providing for alternation of steps of said printed circuit board and said perforated master, means for selectively engaging and disengaging said coupled carrying means from a drive source, and means for locking said printed circuit board against said punching die during each punching operation.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,911,045 November 3, 1959

Theodore M. Wright

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 12, list of References Cited, under UNITED STATES PATENTS, after line 47 insert the following:

2,294,370 Andrews------Sept. 1, 1942

Signed and sealed this 10th day of May 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents