

[54] **INSTRUMENT CONTROL SYSTEM**

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[22] Filed: **June 9, 1971**

[21] Appl. No.: **151,233**

[52] U.S. Cl.**307/92, 307/150, 317/102, 128/303.1, 32/22**

[51] Int. Cl.**H02j 7/00**

[58] Field of Search**317/102; 32/22; 128/303.1; 307/112, 116, 11, 38, 39, 149, 150, 113, 119, 92**

[56] **References Cited**

UNITED STATES PATENTS

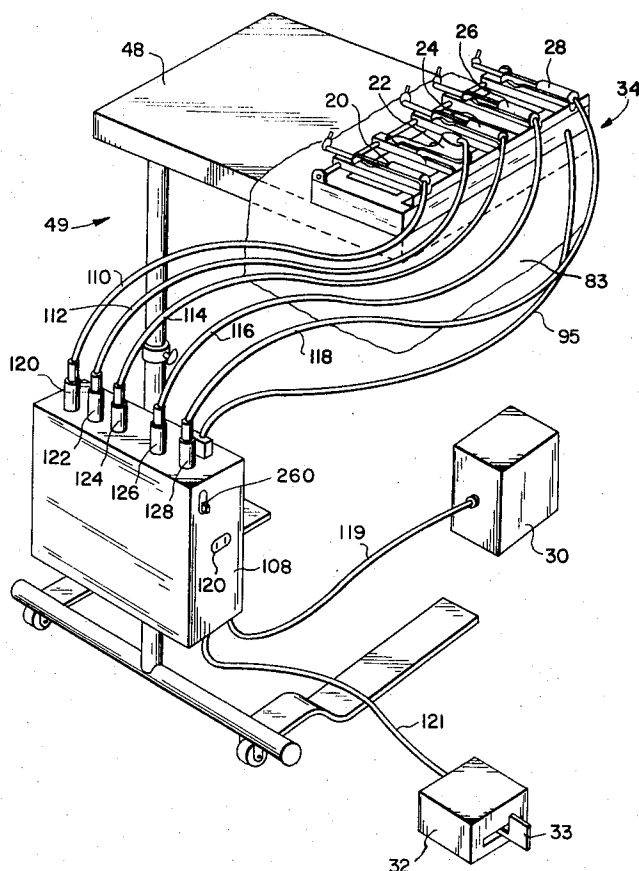
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[57] **ABSTRACT**

A control system is provided for selectively and randomly operating a plurality of surgical instruments from a power source with a single operator controlled switch. The system includes an instrument supporting tray including a plurality of instrument holders for receiving and holding the surgical instruments, a sensing circuit for sensing removal of any one of the surgical instruments from its holder, a power source operated by an operator controlled switch and a control circuit operatively connected to the sensing circuit for connecting the power source to a surgical instrument when it is removed from its holder while preventing the remaining surgical instruments from being operated by the power source.

12 Claims, 6 Drawing Figures



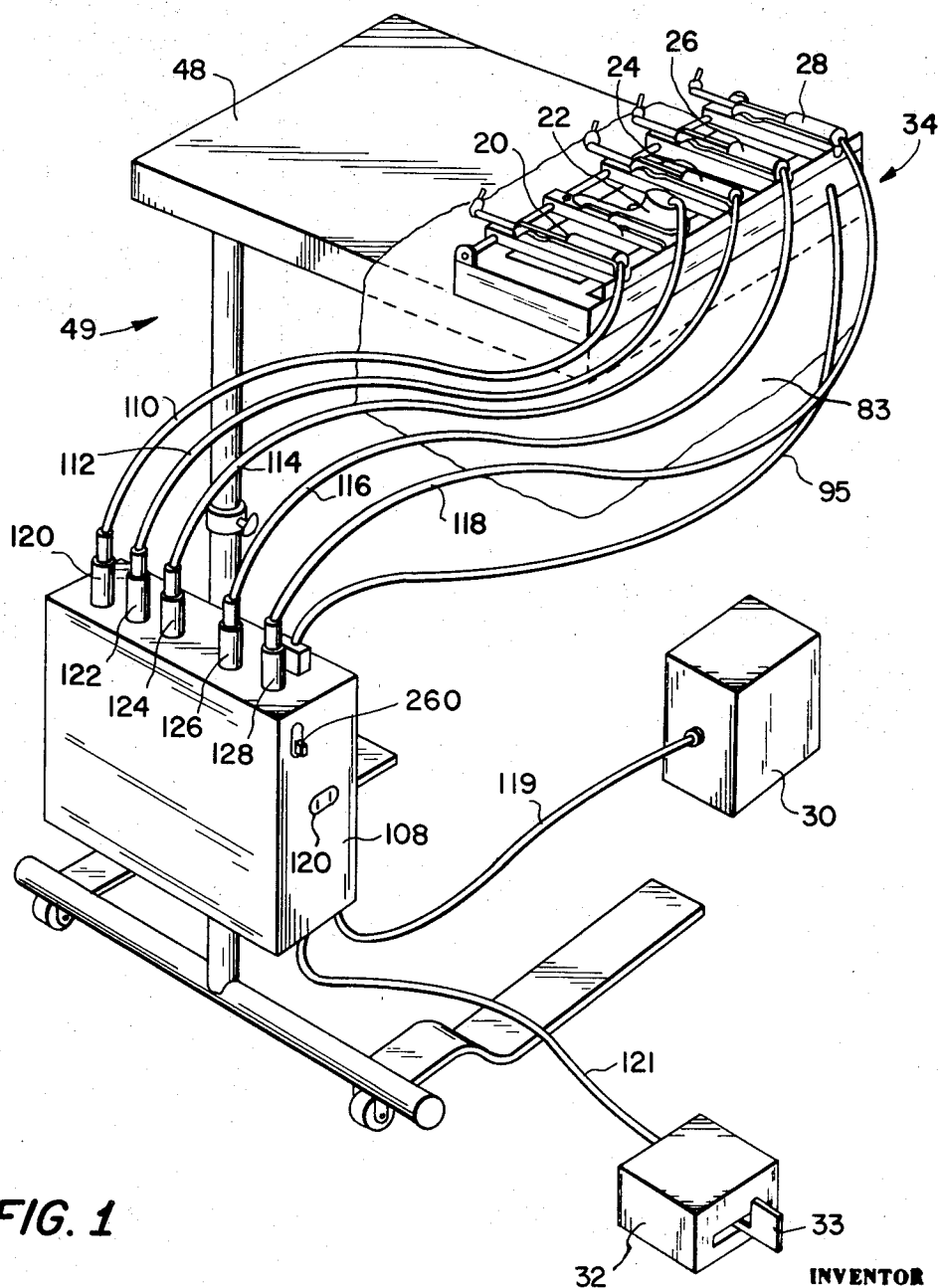


FIG. 1

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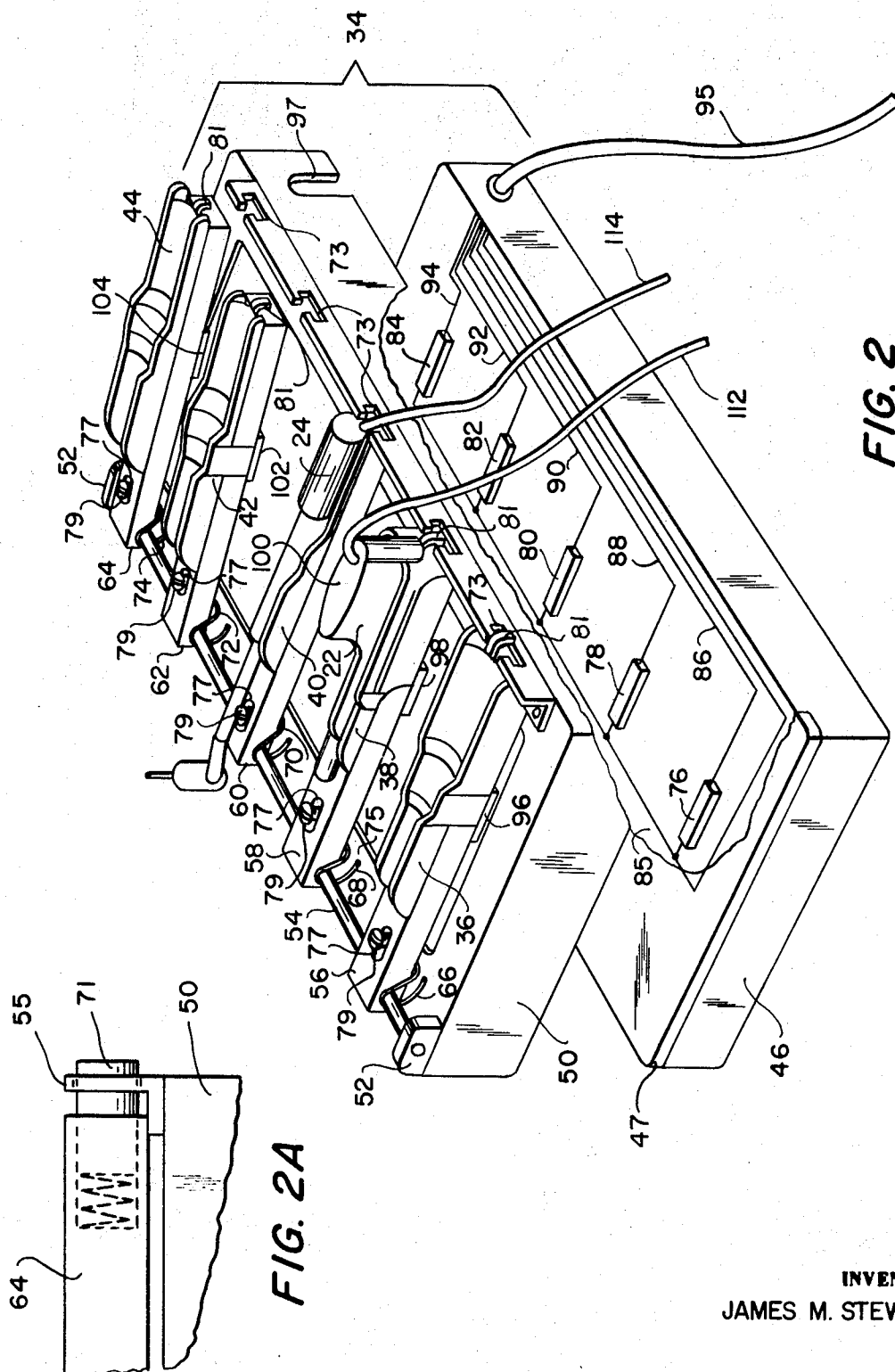


FIG. 2

FIG. 2A

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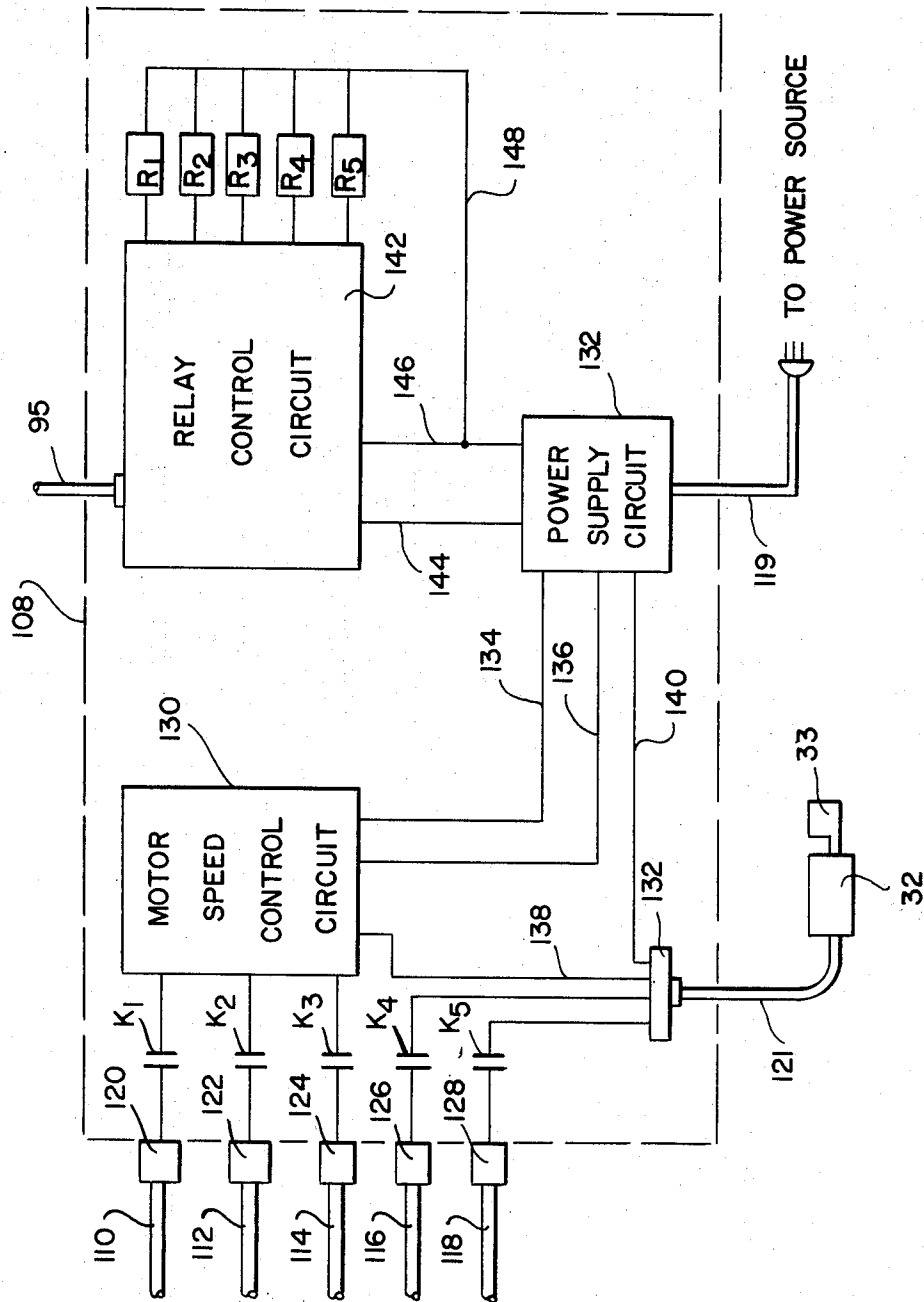


FIG. 3

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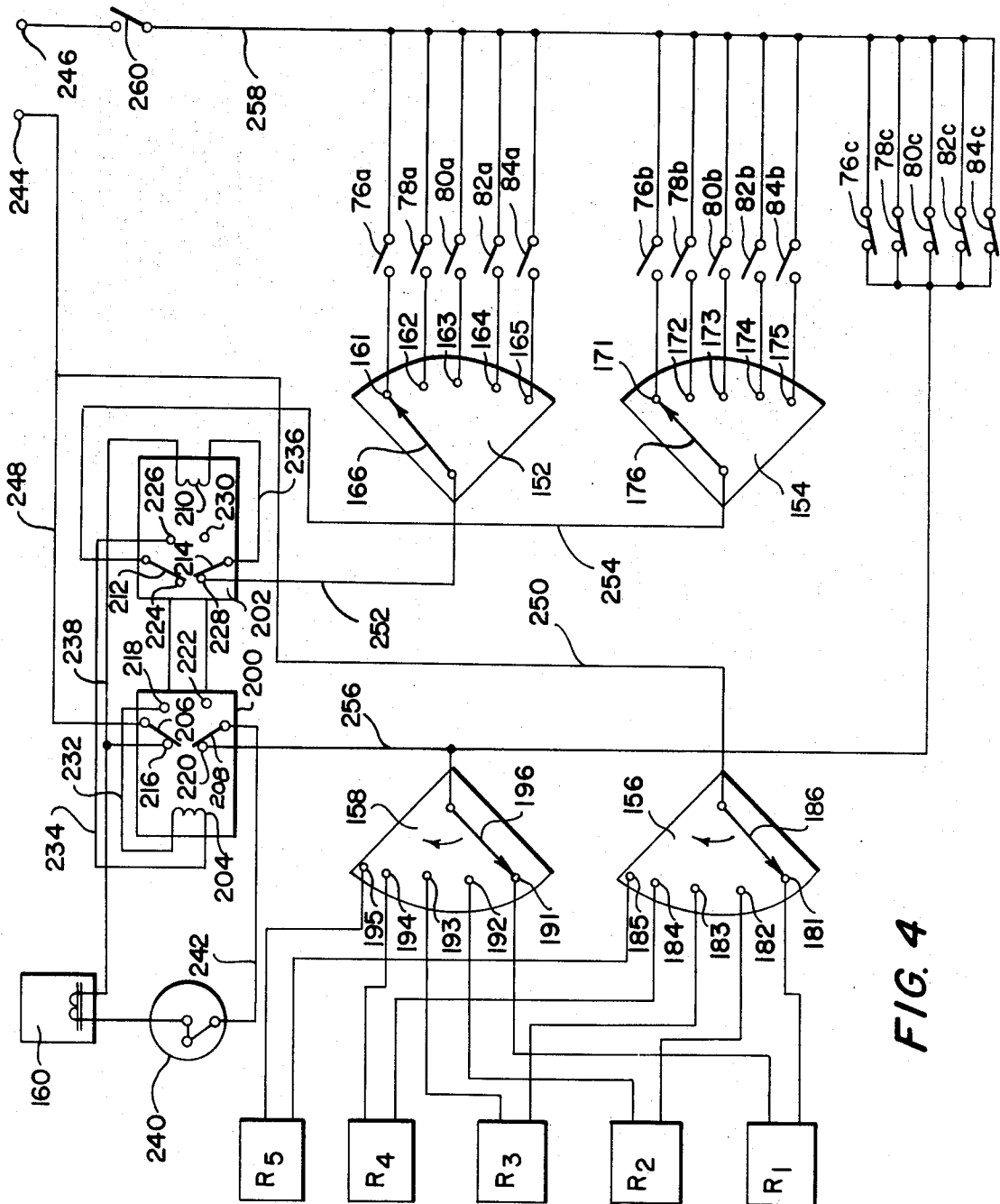


FIG. 4

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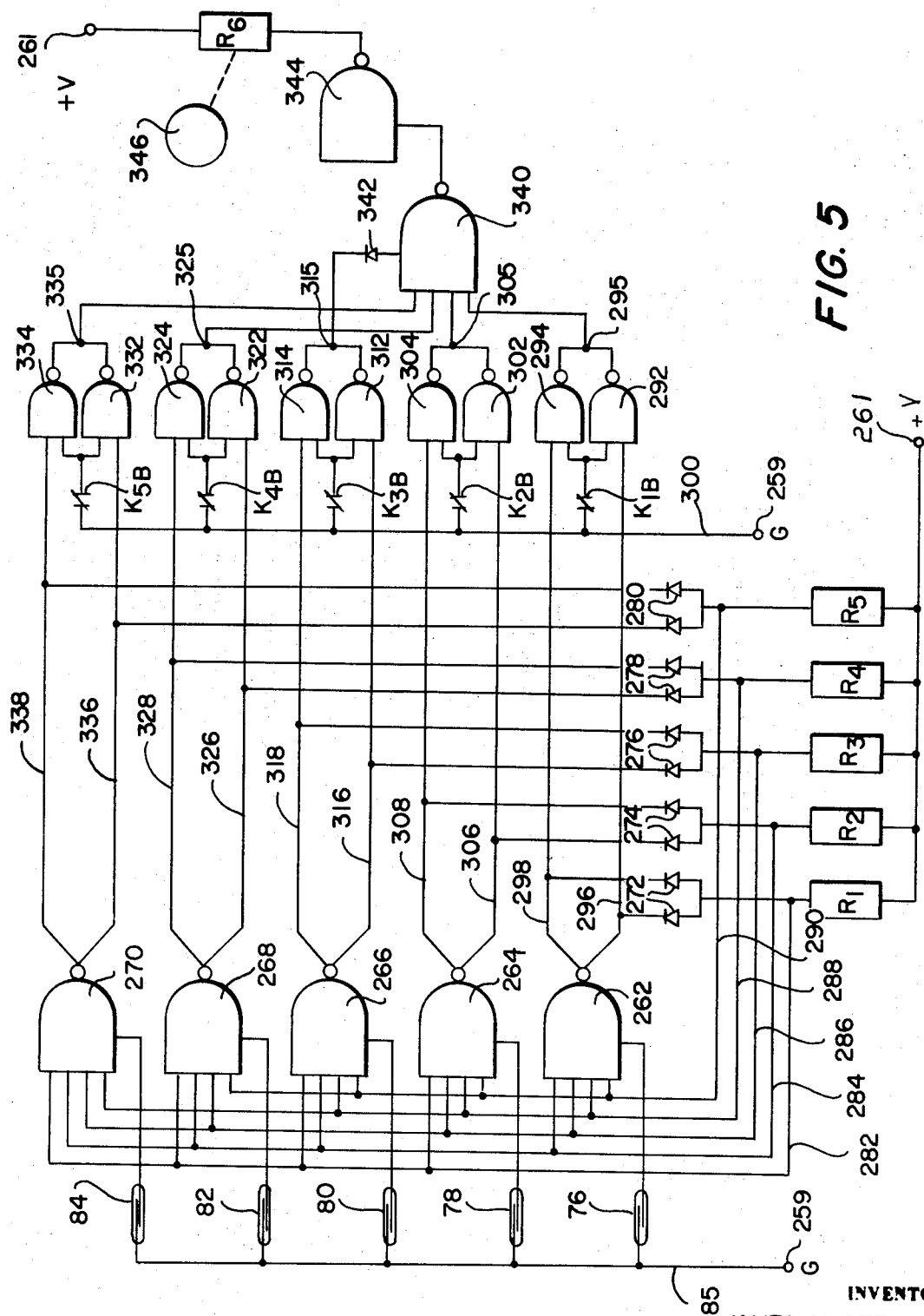


FIG. 5

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INSTRUMENT CONTROL SYSTEM

The present invention relates to an instrument control system and, more particularly, to a control system for selectively operating a plurality of powered instruments from a power source.

In conducting certain surgical operations, it is advantageous to utilize a plurality of mechanized surgical instruments capable of performing different functions. In practice, for example, many different power operated tools, such as drills, chisels, cautery and the like, are often needed to complete an operation on a patient. In using these instruments, or any series of powered surgical instruments, it is desirable that the instruments be readily available for rapid use and in random sequence to minimize errors and the time required for completing the operation. When using power operated tools, it is also desirable to prevent simultaneous operation of two or more instruments to avoid accidental injury to a patient, doctor, or assistant, and particularly to permit idle instruments to be readied or cleansed without the hazard of accidental operation.

Further, it has been found desirable to operate the plurality of instruments through a single foot control switch from a single power source to minimize the number of components required to control the instruments and to reduce the power requirement for operating the instruments. Finally, it is highly desirable to eliminate the hazard of possible electrical shock in the operation of the instruments to avoid accidental electrocution of the patient, doctor, or assistant.

In prior art control systems for surgical instruments, generally the plurality of instruments have been separately connected through a plurality of individual switches to either a single power source or a plurality of separate power sources. While obviously inconvenient in use because many different switches must be operated before an instrument can be used, the prior art systems inherently permit operation of two or more surgical instruments at the same time. Thus, in the prior art systems, it has been necessary to exercise extreme caution in conducting surgical operations to avoid inadvertent operation of the surgical instruments and to avoid injury to the patient, doctor or a person assisting the doctor.

In accordance with the present invention, therefore, a control system is provided for selectively operating a plurality of surgical instruments from a single power source which comprises (1) an instrument supporting means including a plurality of instrument holders for receiving and holding the surgical instruments, (2) sensing means for sensing removal of any one of the surgical instruments from its holder, and (3) control means operatively connected to the sensing means for connecting the power source to a surgical instrument removed from its holder and for preventing the remaining surgical instruments from being operated by the power source.

In a preferred embodiment of the system, each instrument holder is mounted for movement from a first position when a surgical instrument is placed on the holder to a second position when the surgical instrument is removed. The sensing means of the preferred embodiment comprises a plurality of switches mounted on the instrument supporting means adjacent to the instrument holders for detecting movement of any one of

the instrument holders from its first position to its second position upon removal of a surgical instrument from the holder. The control means of the preferred embodiment comprises a plurality of relays for connecting the surgical instruments to the power source and a relay control circuit connected to the switches and responsive to the operation of any one of the switches upon removal of a surgical instrument from its holder for operating the relay connected to the surgical instrument to connect the power source to the surgical instrument and for preventing the remaining relays from being operated until the surgical instrument is replaced in its holder.

The control system permits any one of the surgical instruments to be operated from the power source and prevents the remaining surgical instruments from being simultaneously operated. By limiting the instruments to operation one at a time, the system allows a doctor to select and operate a particular instrument while his assistant can handle any of the remaining instruments without the danger of inadvertent operation. Thus, the control system provides a safeguard against inadvertent operation of two or more surgical instruments and avoids the possibility of accidental injury to the patient, doctor, or assistant.

In addition, the control system has the advantage that a plurality of surgical instruments can be operated through a common foot control switch by a single power source. This advantage permits the control system for operating a plurality of instruments to be simplified and avoids the expense of maintaining a more complicated control system.

Furthermore, the entire system is provided with a common ground to eliminate the possibility of encountering a difference in ground potential in the system. In addition, the operation of the system from a single power source, e.g., a conventional A-C wall outlet, eliminates the possibility of applying voltages which are out of phase to different powered instruments thereby creating an undesired potential difference in the system. Thus, the system of this invention provides electrical protection against accidental shock or electrocution of the patient, doctor, or assistant.

The accompanying drawings illustrate a preferred embodiment of the invention and, together with the description, serve to explain the principles of the invention.

Of the drawings:

FIG. 1 is a perspective view of an instrument control system constructed according to the principles of this invention including an instrument tray having a plurality of instrument holders and a control circuit connected to said instrument tray;

FIG. 2 is an enlarged, perspective view of the instrument tray of FIG. 1 illustrating a plurality of levers pivotally mounted on a frame of the instrument tray for supporting the instrument holders and a plurality of switches mounted on a base of the tray and responsive to movement of the instrument holders;

FIG. 2A is an enlarged elevation view of a portion of one lever of the instrument tray of FIG. 2 illustrating a latch for securing the lever in an inoperative position when the system is operated at less than full capacity;

FIG. 3 is a block diagram of the instrument control system;

FIG. 4 is a schematic diagram of an electromechanical relay control circuit which comprises the control circuit illustrating one embodiment of the instrument control system; and

FIG. 5 is a schematic diagram of a relay control logic circuit which serves as the control circuit in a preferred embodiment of the instrument control system.

The present invention provides a control system for selectively operating a plurality of surgical instruments from a power source. FIG. 1 illustrates a preferred embodiment of the instrument control system for operating a plurality of instruments 20, 22, 24, 26, and 28 from a single power source 30, e.g., a conventional A-C power source.

The system also includes a foot-operated control switch 32 for controlling the amount of power applied to the instruments from power source 30. In the embodiment depicted in FIG. 1, the foot control switch includes a foot-operated lever 33 for controlling the speed and direction of rotation of the instruments. While a single foot control switch is preferred, it is to be understood that any operator controlled switch for controlling the output of the power source may be used with the control system of the present invention.

In accordance with the invention, the control system includes instrument supporting means including a plurality of instrument holders for receiving and holding the surgical instruments. In a preferred embodiment, each instrument holder is mounted for movement from a first position when a surgical instrument is placed on the holder to a second position when the surgical instrument is removed from the holder. As embodied and shown in FIGS. 1 and 2, the instrument supporting means of the preferred embodiment comprises a sterilizable instrument tray 34 including a plurality of sterilizable instrument holders 36, 38, 40, 42, and 44 for receiving and holding sterilizable instruments 20, 22, 24, 26, and 28, respectively. While five holders have been shown in the drawing and the invention will be described as it relates to the control of five separate instruments, it is to be understood that any number of holders may be provided without departing from the scope of this invention.

In addition, it is understood that the invention contemplates instrument supporting means of various types which are not necessarily in the form of instrument trays. The instrument supporting means may comprise, for example, a plurality of individual instrument holders mounted at separate locations in a surgical operating room or doctor's office, or an instrument tray in combination with one or more separate instrument holders, without departing from the scope of the present invention. In the detailed description below, the instrument control system is, for convenience, described in combination with a single instrument tray for supporting a plurality of instruments, but with no intention of limiting the scope of the invention.

Referring to FIG. 2, instrument tray 34 includes a rectangular base 46 having a removable cover 47. Base 46 and cover 47 comprise a non-sterilizable portion of the instrument tray. The base can be placed upon any convenient flat surface to support the instrument tray. As shown in FIG. 1, the base of the instrument tray rests on a platform 48 of a surgical stand 49 on which other surgical equipment can be stored.

Instrument tray 34 (FIG. 2) also includes a rectangular frame 50 which comprises a sterilizable portion of the instrument tray. Frame 50 fits loosely over base 46 to allow isolation of the frame by interposing layers of sterilized cloth, paper, or plastic. A pair of lugs 52 project upward from adjacent corners of frame 50, and a support rod 54 extending longitudinally along one edge of the frame is received in openings formed in the lugs. In addition, frame 50 includes an elongated bracket 55 extending along the opposite edge of the frame and parallel to support rod 54.

The instrument tray of the preferred embodiment includes a plurality of levers 56, 58, 60, 62, and 64 mounted on support rod 54 for movement between upward and downward positions relative to base 46. As shown in FIG. 2, instrument holders 36, 38, 40, 42, and 44 are mounted on levers 56, 58, 60, 62, and 64, respectively.

In addition, the instrument tray includes spring-bias means for biasing each lever into its upward position when an instrument is removed from the instrument holder mounted on the lever and for permitting the lever to move to its downward position when an instrument is placed on the instrument holder. As embodied and shown in FIG. 2, instrument tray 34 includes a plurality of springs 66, 68, 70, 72, and 74 looped around support rod 54 and located adjacent to levers 56, 58, 60, 62, and 64, respectively. Spring 66, for example, includes a lower arm contacting a flat, inwardly projecting ledge 75 on frame 50 and an upper arm engaging the lower surface of lever 56 to urge the lever upward. The remaining springs are similarly designed to urge the corresponding levers upward. The springs are strong enough to bias the corresponding levers and instrument holders into upward positions when the instruments are removed from the holders but permit the levers to move to a downward position when the instruments are replaced on the instrument holders.

The instrument tray of the preferred embodiment also includes latching means for securing each of the levers in its downward position to permit the instrument tray to be operated at less than full capacity. Referring to FIG. 2A, lever 64 includes a latching mechanism comprising a spring-loaded pin 71 projecting from its outermost end. Pin 71 is rectangular in cross-section and bracket 55 includes a rectangular opening 73 (FIG. 2) for receiving the pin to latch lever 64 in its downward position. Similarly, levers 56, 58, 60, and 62 include spring-biased pins and bracket 55 includes corresponding openings for receiving the pins to latch the levers downward.

In the operation of the latching mechanism, with instrument holder 44 mounted on lever 64 an arm 81 (FIG. 2) projecting from the instrument holder engages pin 71 (FIG. 2A) and depresses the pin axially inward relative to the lever and out of engagement with opening 73. The lever is thus free to pivot about support rod 54 between its upward and downward positions. When instrument holder 44 is removed from lever 64, however, pin 71 is biased axially outward relative to the lever. Lever 64 can be latched in its downward position by temporarily depressing pin 71, moving the lever downward, and then releasing the pin to allow it to be biased in the opening 73. The operation of the latching mechanisms of the remaining levers is identical.

Preferably, the instrument tray also includes means for limiting the upward movement of levers when the instruments are removed from their holders. As embodied, this means comprises a plurality of adjustable stop bolts 79 that are threadably mounted in ledge 75 of frame 50 and extend through slots 77 in levers 56, 58, 60, 62, and 64. The bolts can be adjusted with respect to ledge 75 as desired, the heads of the bolts limiting the upward pivotal movement of the levers.

The construction of instrument tray 34 (FIG. 2) in two parts, i.e., base 46 and frame 50, facilitates the performance of aseptic surgery with the plurality of surgical instruments. In sterilizing the instruments for surgery, frame 50 can be removed from base 46 and simultaneously sterilized with the instruments. An appropriate number of layers of sterile cloth 83 (FIG. 1) can be used to cover base 46 and the sterilized frame and instruments can then be placed over the base. The layers of sterile cloth 83 isolate the sterilized instruments from base 46 of the instrument tray. In less stringent or non-sterilized environments, however, the layers of sterile cloth can be eliminated.

In accordance with the invention, the control system also includes sensing means for sensing removal of any one of the surgical instruments from its holder. In the preferred embodiment, a sensing circuit is provided comprising a plurality of switches mounted on the instrument supporting means adjacent to the instrument holders for detecting movement of any one of the instrument holders from its first position to its second position upon removal of a surgical instrument from the instrument holder. Referring to FIG. 2, a plurality of normally open switches 76, 78, 80, 82, and 84 is mounted within base 46 of instrument tray 34 in alignment with levers 56, 58, 60, 62, and 64, respectively. Switches 76, 78, 80, 82, and 84 are connected in parallel by a common conductor 85 and a plurality of conductors 86, 88, 90, 92, and 94, respectively. Common conductor 85 and conductors 86, 88, 90, 92, and 94 are connected to separate conducting elements in a cable 95 (FIGS. 1 and 2) extending from base 46 of the instrument tray.

Switches 76, 78, 80, 82, and 84 respond to movement of levers 56, 58, 60, 62, and 64, respectively, between the upward and downward positions. Switch 76, for example, is open when lever 56 is moved to its upward position and is closed when the lever is moved to its downward position. Similarly, the remaining switches are open when the corresponding levers are moved to upward positions and closed when the levers are moved to downward positions.

In a preferred embodiment of the sensing circuit, switches 76, 78, 80, 82, and 84 are magnetic feed switches (FIG. 5) having normally open contacts. To operate the switches, and referring to FIG. 2, a plurality of magnets 96, 98, 100, 102, and 104 are mounted on the lower surfaces of levers 56, 58, 60, 62, and 64, respectively, in alignment with magnet reed switches 76, 78, 80, 82, and 84. When, for example, lever 56 is moved to its downward position, and as is well known to those skilled in the art, the magnetic field of magnet 96 causes the normally open contacts of magnetic reed switch 76 to close. However, and as shown in FIG. 5, when lever 56 is moved to its upward position by lifting an instrument out of holder 36 the contacts of magnetic

reed switch 76 return to their normally open position. The normally open contacts of magnetic feed switches 78, 80, 82, and 84 are similarly operated by magnets 98, 100, 102, and 104 on levers 58, 60, 62, and 64, respectively.

In an alternative embodiment of the sensing circuit, switches 76, 78, 80, 82, and 84 comprise a plurality of microswitches mounted on base 46 for operatively engaging levers 56, 58, 60, 62, and 64, respectively. The microswitches include plungers (not shown) for engaging the corresponding levers and three pairs of contacts operated by movement of the plungers.

Referring to FIG. 4, microswitch 76 includes a first pair of normally open contacts 76a, a second pair of normally open contacts 76b, and a third pair of normally closed contacts 76c. When lever 56 is moved to its upward position, contacts 76a and 76b are open and contacts 76c are closed, and when the lever is moved to its downward position, contacts 76a and 76b are closed and contacts 76c are open. Similarly, microswitches 78, 80, 82, and 84 include normally open contacts 78a and 78b, 80a and 80b, 82a and 82b, and 84a and 84b, respectively, and normally closed contacts 78c, 80c, 82c, and 84c, respectively.

In embodiments of the instrument control system which include separate instrument holders mounted at diverse locations, e.g., in the less stringent environment of a doctor's office, each separate instrument holder can incorporate a separate switch element for sensing removal of the instrument supported in the holder. The switch elements can be connected to the instrument control system in the same manner as the switches of instrument tray 34 to control the operation of surgical instruments located in the separate instrument holders.

In accordance with the invention, the instrument control system further includes control means operatively connected to the sensing means for connecting the power source to a surgical instrument removed from its holder and for preventing the remaining surgical instruments from being operated by the power source. As embodied and shown in FIG. 1, a control circuit 108 is mounted on surgical stand 49 and connected by cable 95 to the sensing circuit of instrument tray 34. A notch 97 (FIG. 2) is formed in frame 50 of the instrument tray for receiving cable 95 when the frame is placed over base 46.

Control circuit 108 (FIG. 2) is also connected to instruments 20, 22, 24, 26, and 28 by a plurality of conductors 110, 112, 114, 116, and 118, respectively. In addition, power source 30 and foot control switch 32 are connected to the control circuit by conductors 119 and 121, respectively. The control circuit includes a conventional electrical outlet 120 to allow auxiliary electric equipment to be connected to the instrument control system and to the common ground of the system.

The control circuit of the preferred embodiment includes a plurality of relays for connecting the surgical instruments to the power source and a relay control circuit connected to the switches of the sensing circuit. The relay control circuit is responsive to actuation of any one of the switches upon removal of a surgical instrument to connect the power source to the surgical instrument and to prevent the remaining relays from being operated until the surgical instrument is replaced in its holder.

Referring to FIG. 3, control circuit 108 includes a plurality of relays R_1 , R_2 , R_3 , R_4 , and R_5 having normally open contacts K_1 , K_2 , K_3 , K_4 , and K_5 , respectively. Conductors 110, 112, 114, 116, and 118 of the instruments are connected to the control circuit by connectors 120, 122, 124, 126, and 128, respectively. Connectors 120, 122, and 124 are connected to a motor speed control circuit 130 through normally open relay contacts K_1 , K_2 , K_3 . The instruments connected to conductors 110, 112, and 114 include self-contained motors and thus it is necessary to connect these instruments to the motor speed control circuit to allow the speed of operation of these instruments to be controlled.

As shown in FIG. 3, motor speed control circuit 130 is connected to a power supply circuit 132 by a pair of conductors 134 and 136. The power supply circuit converts the power applied to control circuit 108 from power source 30 to appropriate D-C voltages for operating the control circuit.

Foot control switch 32 is connected to control circuit 108 by a connector 132 (FIG. 3). Connector 132 is connected to motor speed control circuit 130 by a conductor 138 and to power supply circuit 132 by a conductor 140. It is thus possible to control the speed of operation of the instruments connected to conductors 110, 112, and 114 by operating foot lever 33 of the foot control switch 32.

As shown in FIG. 3, connectors 126 and 128 are connected through normally open contacts K_4 and K_5 of relays R_4 and R_5 , respectively, to foot control connector 132. It is thus possible to connect the instruments connected to conductors 116 and 118 directly to power supply circuit by operation of foot control switch 32.

Control circuit 108 also includes a relay control circuit 142 (FIG. 3). The relay control circuit is connected to the sensing circuit of instrument tray 34 by cable 95 and to power supply circuit 132 by conductors 144 and 146. Relays R_1 , R_2 , R_3 , R_4 , and R_5 are connected to relay control circuit 142 and to power supply circuit 132 by a common conductor 148.

FIG. 4 illustrates an electromechanical circuit which constitutes the relay control circuit of a preferred embodiment of the system. The electromechanical circuit includes a rotary stepping switch, shown schematically as four segments 152, 154, 156, and 158, and stepping coil 160 for intermittently advancing the rotary stepping switch.

As shown in FIG. 4, each segment of the rotary stepping switch includes five stationary contacts and a single rotary contact which can be moved into successive engagement with the stationary contacts. Segment 152 includes five stationary contacts 161, 162, 163, 164, and 165 connected to contacts 76a, 78a, 80a, and 84a, respectively, of microswitches 76, 78, 80, 82, and 84 and a rotary contact 166. Similarly, segment 154 includes five stationary contacts 171, 172, 173, 174, and 175 connected to contacts 76b, 78b, 80b, 82b, and 84b, respectively, of the microswitches and a rotary contact 176. Segment 156 includes five stationary contacts 181, 182, 183, 184, and 185 connected to first terminals on relays R_1 , R_2 , R_3 , R_4 , and R_5 , respectively, and a rotary contact 186. Segment 158 includes five stationary contacts 191, 192, 193, 194, and 195 connected to second terminals on relays R_1 , R_2 , R_3 , R_4 , and R_5 , respectively, and a rotary contact 196. In the operation of the rotary stepping switch, stepping coil 160 is

intermittently energized to advance rotary contacts 166, 176, 186, and 196 of the rotary stepping switch successively into engagement with the stationary contacts on segments 152, 154, 156, and 158, respectively, of the rotary switch.

The electromechanical circuit (FIG. 4) includes a pair of interconnected latching relays 200 and 202 for intermittently energizing stepping coil 160. Latching relay 200 includes coil 204 for operating a pair of contact arms 206 and 208. Similarly, latching relay 202 includes a coil 210 for operating a pair of contact arms 212 and 214. Latching relay 200 includes a first pair of stationary contacts 216 and 218 for engaging contact arm 206 and second pair of stationary contacts 220 and 222 for engaging contact arm 208. Similarly, latching relay 202 includes a first pair of stationary contacts 224 and 226 for engaging contact arm 212 and a second pair of stationary contacts 228 and 230 for engaging contact arm 214.

In the operation of latching relays 200 and 202, the alternate energization of coils 204 and 210 results in alternate leftward and rightward movement of contact arms 206 and 208 into engagement with contacts 216 and 218 and contacts 220 and 222, respectively. Similarly, contact arms 212 and 214 are moved leftward and rightward between contacts 224 and 226 and contacts 228 and 230, respectively.

As shown in FIG. 4, coil 204 of latching relay 200 is connected to stationary contact 218 of latching relay 200 by conductor 232 and to stationary contact 226 of latching relay 202 by conductor 234. Coil 210 of latching relay 202 is connected to contact arm 214 of latching relay 202 by a conductor 236 and to stationary contact 216 of latching relay 200 by a conductor 238.

Stepping coil 160 of the rotary stepping switch is connected by conductor 238 to stationary contact 216 of latching relay 200 and to coil 210 of latching relay 202. In addition, stepping coil 160 is connected to contact arm 208 of latching relay 200 through a normally closed switch 240 and a conductor 242.

The electromechanical circuit includes a pair of power supply terminals 244 and 246 connected to power supply circuit 132 (FIG. 3) by conductors 144 and 146, respectively. As shown in FIG. 4, contact arm 206 of latching relay 200 is connected to power supply terminal 244 by a conductor 248. In addition, rotary contact 186 of segment 156 of the rotary stepping switch is connected to power supply terminal 244 by a conductor 250.

Rotary contact 166 of segment 152 of the rotary stepping switch is connected to stationary contact 228 of latching relay 202 by a conductor 252, and rotary contact 176 of segment 154 of the rotary stepping switch is connected to contact arm 212 of latching relay 202 by a conductor 254. Finally, rotary contact 196 of segment 158 of the rotary stepping switch is connected to stationary contact 220 of latching relay 200 by a conductor 256.

As shown in FIG. 4, normally closed contacts 76c, 78c, 80c, 82c, and 84c of microswitches 76, 78, 80, 82, and 84, respectively, are connected in parallel to conductor 256 of the electromechanical circuit. In addition, normally open contacts 76a, 78a, 80a, and 84a, normally open contacts 76b, 78b, 80b, 82b, and 84b, and normally closed contacts 76c, 78c, 80c, 82c, and

84c are connected to a common conductor 258 which, in turn, is connected to power supply terminal 246 through an on-off switch 260.

In the operation of the instrument control system incorporating the electromechanical relay control circuit (FIG. 4), five instruments are placed on instrument holders 36, 38, 40, 42, and 44 (FIG. 2) to move levers 56, 58, 60, 62, and 64 of instrument tray 34 to their downward positions. If it is desired to operate less than five instruments with the control system, the levers corresponding to the unused holders can be latched in downward positions. With levers 56, 58, 60, 62, and 64 in downward positions, normally open contacts 76a, 78a, 80a, 82a, and 84a (FIG. 4) and normally open contacts 76b, 78b, 80b, 82b and 84b are closed while normally closed contacts 76c, 78c, 80c, 82c, and 84c are open. On-off switch 260 is closed to energize the electromechanical circuit from power supply circuit 132 (FIG. 3).

If, for example, instrument 24 placed on instrument holder 40 is then removed, lever 60 is biased into its upward position by spring 70 and microswitch 80 is operated to open contacts 80a and 80b and close contacts 80c. Coil 210 of latching relay 202 is actuated through a closed circuit to power supply terminals 244 and 246 including closed contacts 76a of microswitch 76, stationary contact 161 and rotary contact 166 of segment 152 of the rotary stepping switch, contact arm 214 of latching relay 202, conductors 236 and 238, and contact arm 206 of latching relay 200. At the same time, stepping coil 160 of the rotary stepping switch is actuated through a closed circuit to power supply terminals 244 and 246 including contacts 80c, conductor 256, contact arm 208 of latching relay 200, conductors 242 and 238, and contact arm 206 of latching relay 200.

As a result of the actuation of coil 210, contact arms 206 and 208 of latching relay 200 and contact arms 212 and 214 of latching relay 202 are driven rightward and latched. Since stepping coil 160 is simultaneously actuated, rotary contacts 166, 176, 186, and 196 of the rotary stepping switch advance by one step into engagement with stationary contacts 162, 172, 182, and 192, respectively.

Next, with contact arms 206, 208, 210, and 212 latched to the right in latching relays 200 and 202, coil 204 of latching relay 200 is actuated through a closed circuit to the power supply terminals including contacts 78b, stationary contact 172 and rotary contact 176 of segment 154 of the rotary stepping switch, conductor 254, contact arm 212 of latching relay 202, conductors 234 and 232, and contact arm 206 of latching relay 200. Stepping coil 160 is not actuated, at this time, to advance the rotary stepping switch because contact arm 208 of latching relay 200 is latched to the right, out of engagement with stationary contact 220. As a result of the actuation of coil 204, however, contact arms 206, 208, 210, and 212 of the latching relays are driven leftward and latched in the positions illustrated in FIG. 4.

With rotary contacts 166, 176, 186, and 196 of the rotary stepping switch in engagement with stationary contacts 162, 172, 182, and 192, respectively, the operation of latching relays 200 and 202, as described above, is repeated. Coil 210 of latching relay 202 is ac-

tuated to drive contact arms 206, 208, 210, and 212 rightward, and stepping coil 160 is simultaneously actuated to advance rotary contacts 166, 176, 186, and 196 of the rotary stepping switch by one step into engagement with the stationary contacts 163, 173, 183, and 193, respectively.

Since contacts 80b are open, relay coil 204 is not actuated and contact arms 206, 208, 210, and 212 remain latched to the right. The operation of latching relays 200 and 202 and the rotary stepping switch is thus terminated with rotary contacts 166, 176, 186, and 196 of the rotary stepping switch in engagement with stationary contacts 163, 173, 183, and 193, respectively. At this time, relay R₃ is energized through a closed circuit to power supply terminals 244 and 246 including conductor 250, rotary contacts 186 and 196 of the rotary stepping switch, conductor 256, and closed contacts 80c of microswitch 80 to close relay contacts K₃ (FIG. 3).

The closing of contacts K₃ connects instrument 24 (FIG. 1) to power supply circuit 132 (FIG. 3) through motor speed control circuit 130 and permits the instrument to be operated from power source 30 (FIG. 1) under the control of foot control switch 32. As explained above, the foot control switch can be used to perform both on-off and speed control functions for the instrument.

The electromechanical circuit (FIG. 4) permits instrument 24 to be operated from power source 30 until it is replaced in instrument holder 40 (FIG. 1) and, at the same time, prevents the remaining instruments from being connected to the power source. Thus, it is possible for an assistant to remove any one of the remaining instruments from the instrument tray for cleaning or other purposes without the danger of inadvertent operation of the instrument.

While the doctor is using instrument 24 in an operation on a patient, his assistant can prepare the next surgical instrument for use in the operation with no possibility of accidental injury to the doctor, patient, or assistant. If, for example, instrument 22 is the next to be used, it can be removed from instrument holder 36 (FIG. 1) by the assistant and prepared for use. As a result of the removal of instrument 22 from instrument holder 36, lever 56 (FIG. 2) is biased to its upward position and microswitch 76 is actuated to open contacts 76a and 76b and to close contacts 76c. The closing of contacts 76c has no effect, at this time, on stepping coil 160 of the rotary stepping switch because contact arm 208 of latching relay 200 is latched to the right, as previously explained. Thus, rotary contacts 176, 186, 196, and 206 remain in engagement with stationary contacts 163, 173, 183, and 193, respectively, to maintain relay R₃ energized to permit instrument 24 to be operated under the control of foot control switch 32.

When instrument 24 is replaced on instrument holder 40, however, lever 60 is moved to its downward position and microswitch 80 is actuated to close contacts 80a and 80b and to open contacts 80c. With contacts 80b closed, coil 204 of latching relay 200 is actuated through a closed circuit including contacts 80b, stationary contact 173 and rotary contact 176 of segment 154 of the rotary stepping switch, conductor 254, contact arm 212 of latching relay 202, conductors 234

and 232, and contact arm 206 of latching relay 200 to drive contact arms 206, 208, 210, and 212 of the latching relays leftward.

The rotary stepping switch is again intermittently operated to advance rotary contacts 166, 176, 186, and 196. As rotary contacts 186 and 196 move out of engagement with stationary contacts 183 and 193, respectively, relay R_3 is de-energized and relay contacts K_3 are opened to disable instrument 24. When rotary contacts 166, 176, 186, and 196 move into engagement with stationary contacts 161, 171, 181, and 191, respectively, contact arms 206, 208, 210, and 212 of latching relays 200 and 202 are latched to the right because contacts 76b are open with instrument 20 removed from holder 36, and the operation of the rotary stepping switch is again terminated. At this time, relay R_1 is energized to close contacts K_1 (FIG. 3) to connect instrument 22 to power supply circuit 132 through motor speed control circuit 130. Thus, instrument 22 can be operated from power source 30 under the control of foot control switch 32.

FIG. 5 illustrates a logic circuit which constitutes the relay control circuit of a preferred embodiment of the system. The relay control logic circuit includes a first pair of input terminals 259 connected to power supply circuit 132 (FIG. 3) by conductor 144 to apply a binary "0" signal, i.e., a low or ground voltage (G), to the circuit. In addition, a second pair of input terminals 261 (FIG. 5) are connected to power supply circuit 132 by conductor 144 (FIG. 3) to apply a binary "1" signal, i.e., a high voltage (+V), to the relay control circuit.

Referring to FIG. 5, the relay control logic circuit includes a first set of NAND gates 262, 264, 266, 268, and 270 and a second set of NAND gates (not shown) identical to and connected in parallel with NAND gates 262, 264, 266, 268, and 270. This second set of NAND gates constitutes a redundant circuit which permits the relay control logic circuit to operate in the event of any failure in NAND gates 262, 264, 266, 268, or 270.

As shown in FIG. 5, each NAND gate includes five input terminals and a single output terminal. In operation, each NAND gate produces a binary "0" output signal when binary "1" signals are applied to all of its input terminals and it produces a binary "1" output signal when one or more of the input signals is a binary "0."

Referring to FIG. 5, a first input terminal of NAND gate 262 is connected to magnetic reed switch 76 of the sensing circuit of instrument tray 34. Similarly, first input terminals of NAND gates 264, 266, 268, and 270 are connected to magnetic reed switches 78, 80, 82, and 84, respectively. In addition, the redundant NAND gates (not shown), in parallel with NAND gates 262, 264, 266, 268 and 270 are similarly connected to the magnetic reed switches.

As shown in FIG. 5, relay R_1 is connected to the output terminals of NAND gate 262 and its corresponding, redundant NAND gate (not shown) by a pair of diodes 272. Similarly, a pair of diodes 274 connects relay R_2 to the output terminals of NAND gate 264 and its redundant NAND gate (not shown) and a pair of diodes 276 connects relay R_3 to the output terminals of NAND gate 266 and its redundant NAND gate (not shown). In addition, relay R_4 is connected to the output terminals of NAND gate 268 and its redundant NAND gate (not

shown) by a pair of diodes 278, and relay R_5 is connected to the output terminals of NAND gate 270 and its redundant NAND gate (not shown) by a pair of diodes 280.

Referring to FIG. 5, relay R_1 is connected to input terminals of NAND gates 264, 266, 268, and 270 by a conductor 282, and relay R_2 is connected to input terminals of NAND gates 262, 266, 268, and 270 by a conductor 284. In addition, a conductor 286 connects relay R_3 to input terminals of NAND gates 262, 264, 268, and 270, and a conductor 288 connects relay R_4 to input terminals of NAND gates 262, 264, 266, and 270. Finally, relay R_5 is connected to input terminals of NAND gates 262, 264, 266, and 268 by conductor 290. Relays R_1 , R_2 , R_3 , R_4 , and R_5 are similarly connected to the redundant NAND gates (not shown) in parallel connection with NAND gates 262, 264, 266, 268, and 270.

The relay control logic circuit also includes a third set of NAND gates for monitoring the operation of NAND gates 262, 264, 266, 268, and 270 and the redundant NAND gates. As shown in FIG. 5, a pair of NAND gates 292 and 294 are interconnected to provide a first logic "OR" circuit. The output terminals of NAND gates 292 and 294 are connected together to provide a common output 295. A first input terminal of NAND gate 292 is connected by a conductor 296 to the output terminal of NAND gate 262, and a first input terminal of NAND gate 294 is connected by a conductor 298 to the output terminal of the redundant NAND gate (not shown) connected in parallel with NAND gate 262. NAND gates 292 and 294 have second input terminals connected to a conductor 300 through normally closed contacts K_{1B} operated by relay R_1 .

In addition, a pair of NAND gates 302 and 304 are interconnected to provide a second logic "OR" circuit. The output terminals of NAND gates 302 and 304 are connected together to provide a common output 305. A first input terminal of NAND gate 302 is connected by a conductor 306 to the output terminal of NAND gate 264, and a first input terminal of NAND gate 304 is connected by a conductor 308 to the output terminal of the redundant NAND gate (not shown) connected in parallel with NAND gate 264. NAND gates 302 and 304 have second input terminals connected to conductor 300 through normally closed contacts K_{2B} operated by relay R_2 .

Similarly, a pair of NAND gates 312 and 314 are interconnected to provide a third logic "OR" circuit. NAND gates 312 and 314 have a common output 315, and first input terminals of NAND gates 312 and 314 are connected to the output terminals of NAND gate 266 and the redundant NAND gate (not shown) connected in parallel with NAND gate 266 by conductors 316 and 318, respectively. NAND gates 312 and 314 also have second input terminals connected to conductor 300 through normally closed contacts K_{3B} operated by relay R_3 .

Further, a pair of NAND gates 322 and 324 are interconnected to provide a fourth logic "OR" circuit. NAND gates 322 and 324 have a common output 325, and first input terminals of NAND gates 322 and 324 are connected to the output terminals of NAND gate 268 and the redundant NAND gate (not shown) con-

nected in parallel with NAND gate 268 by conductors 326 and 328, respectively. NAND gates 322 and 324 also have second input terminals connected to conductor 300 through normally closed contacts K_{4B} operated by relay R_4 .

Finally, a pair of NAND gates 332 and 334 are interconnected to provide a fifth logic "OR" circuit having a common output 335. NAND gates 332 and 334 have first input terminals connected to the output terminals of NAND gate 270 and the redundant NAND gate (not shown) connected in parallel with NAND gate 270 by conductors 336 and 338, respectively, and second input terminals connected to conductor 300 through normally closed contacts K_{5B} operated by relay R_5 .

In operation, each logic "OR" circuit produces a binary "0" output signal only when binary "1" input signals are applied to both inputs of either NAND gate in the circuit. The logic "OR" circuit produces a binary "1" output signal for all other input signal combinations. The first logic "OR" circuit, i.e., NAND gates 292 and 294, normally produces a binary "1" signal at output 295 because binary "1" signals are applied to the first inputs of NAND gates 292 and 294 by conductors 296 and 298, respectively, and a binary "0" signal (G) is applied to the second inputs of NAND gates 292 and 294 through normally closed contacts K_{1B} . The operation of the remaining logic "OR" circuits is identical to the first logic "OR" circuit so that binary "1" signals normally appear at outputs 305, 315, 325, and 335.

As shown in FIG. 5, the relay control logic circuit includes a NAND gate 340 having its input terminals connected to outputs 295, 305, 315, 325, and 335 of the logic "OR" circuits. A diode 342 connects output 315 of NAND gates 312 and 314 to one of the input terminals of NAND gate 340. Since binary "1" signals are normally applied to all input terminals of NAND gate 340, a binary "0" signal normally appears at the output terminal of the NAND gate.

An inverter 344 (FIG. 5) is connected to the output of NAND gate 340 and, in turn, is connected to relay R_6 . The relay is also connected to input terminal 261 of the logic circuit and operates an indicator light 346 to indicate failure of any one of NAND gates 262, 264, 266, 268, and 270 of the redundant NAND gates (not shown). Since a binary "0" signal is normally applied to inverter 344 from NAND gate 340, the inverter normally produces a binary "1" signal and relay R_6 is unactuated.

In the operation of the instrument control system incorporating the relay control logic circuit of FIG. 5, five instruments are placed on instrument holders 36, 38, 40, 42, and 44 (FIG. 2) to move levers 56, 58, 60, 62, and 64 of instrument tray 34 to their downward positions. If it is desired to operate less than five instruments with the control system, the levers corresponding to the unused holders can be latched in downward positions. With levers 56, 58, 60, 62, and 64 in downward positions, magnets 96, 98, 100, 102, and 104 are positioned adjacent to magnetic reed switches 76, 78, 80, 82, and 84, respectively, to close the magnetic reed switches.

With magnetic reed switches 76, 78, 80, 82, and 84 closed, binary "0" signals are applied to the first input terminals of NAND gates 262, 264, 266, 268, and 270.

The NAND gates thus produce binary "1" output signals which are applied to diodes 272, 274, 276, 278, and 280 and transmitted to relays R_1 , R_2 , R_3 , R_4 , and R_5 , respectively. Since a binary "1" voltage (+V) is also applied to relays R_1 , R_2 , R_3 , R_4 , and R_5 from input terminal 261, there is no potential difference applied to the relays and the relays are thus inoperative.

The binary "1" signals applied to relays R_1 , R_2 , R_3 , R_4 , and R_5 through diodes 272, 274, 276, 278, and 280 are also applied by conductors 282, 284, 286, 288, and 290 to the remaining input terminals of NAND gates 262, 264, 266, 268, and 270.

When instrument 26 is removed from instrument holder 42 (FIG. 2), for example, magnetic reed switch 82 (FIG. 5) is opened and a binary "1" input signal is applied to the first input terminal of NAND gate 268. Since, as previously explained, binary "1" signals are also applied to the remaining input terminals of NAND gate 268, a binary "0" signal appears at the output terminal of NAND gate 268 and is transmitted through diodes 278 to relay R_4 . A potential difference is applied to relay R_4 by virtue of the binary "1" signal (+V) applied to the relay from input terminal 261, and relay R_4 is thus actuated to close relay contacts K_4 (FIG. 3) and to open relay contacts K_{4B} (FIG. 5).

The closing of relay contacts K_4 (FIG. 3) connects instrument 26 to power supply circuit 132 through motor speed control circuit 130 and permits the instrument to be operated from power source 30 (FIG. 1) under the control of foot control switch 32. The simultaneous opening of relay contacts K_{4B} has no effect, as explained below, on the output signal produced by NAND gates 322 and 324 in normal operation of the relay control logic circuit.

The binary "0" signal applied to relay R_4 through diodes 278 is simultaneously applied by conductor 288 to input terminals of NAND gates 262, 264, 266, and 270 to inhibit the NAND gates. NAND gates 262, 264, 266, and 270 thus produce binary "1" output signals which are transmitted to relays R_1 , R_2 , R_3 , and R_5 through diodes 272, 274, 276, and 280, respectively. If any other instrument is removed from the holder before instrument 26 is replaced in holder 42, the operation of the relay control logic circuit is unchanged because NAND gates 262, 264, 266, and 270 are inhibited and cannot respond to the actuation of magnetic reed switches 76, 78, 80, and 84, respectively. The remaining instruments are thus disabled and cannot be operated from power source 30 until instrument 26 is replaced in instrument holder 42.

The redundant circuit provides increased reliability in the operation of the relay control logic circuit of FIG. 5. The redundant circuit permits the relay control logic circuit to function properly in the event of failure of any one of NAND gates 262, 264, 266, 268, and 270 while indicating the occurrence of a failure.

In normal operation of the relay control logic circuit, NAND gate 268 and its redundant NAND gate both produce binary "1" output signals before instrument 24 is removed from instrument holder 42 to open magnetic reed switch 82. The binary "1" signals are applied to the first input terminals of NAND gates 322 and 324 by conductors 326 and 328, respectively. Binary "0" signals (G) are simultaneously applied to the second input terminals of NAND gates 322 and 324 through

normally closed relay contacts K_{4B} . With a binary "1" signal at its first input terminal and a binary "0" signal at its second input terminal, each NAND gate produces a binary "1" output signal which is applied to common output 325.

When instrument 24 is removed from its holder to open magnetic reed switch 82, the binary "1" output signals of NAND gate 268 and its redundant NAND gate both change to binary "0" signals which are applied to relay R_4 and to the first input terminals of NAND gates 322 and 324. Since relay contacts K_{4B} are simultaneously opened to apply binary "0" signals to the second input terminals of NAND gates 322 and 324, however, the binary "1" output signals produced by the NAND gates are unchanged.

If, for example, NAND gate 268 fails to respond when magnetic reed switch 82 is opened and continues to produce a binary "1" signal, the redundant NAND gate (not shown) connected in parallel with NAND gate 268 produces a binary "0" signal which is applied to relay R_4 through diode 278 connected to conductor 328 to actuate the relay. The binary "1" signal produced by NAND gate 268 is isolated from relay R_4 by diode 278 connected to conductor 326.

The binary "1" signal produced by NAND gate 268 is applied by conductor 326 to the first input terminal of NAND gate 322, and the binary "0" signal produced by the NAND gate (not shown) connected in parallel with NAND gate 268 is applied by conductor 328 to the first input terminal of NAND gate 324. The actuation of relay R_4 opens normally closed contacts K_{4B} to apply binary "1" and binary "0" input signals are applied to NAND gate 324, the NAND gate produces a binary "1" output signal. With binary "1" signals at both input terminals of NAND gate 322, however, the NAND gate produces a binary "0" output signal which results in a binary "0" signal at common output terminal 325. This binary "0" signal is applied to NAND gate 340 to change the output signal of NAND gate 340 from a binary "0" to binary "1." The binary "1" signal produced by NAND gate 340 is inverted to a binary "0" signal by inverter 344 and applied to relay R_6 . Since a binary "1" signal (+V) is applied to relay R_6 from input terminal 261, the relay is operated by the resulting potential difference and indicator light 346 is turned on to indicate that one of the NAND gates, i.e., NAND gate 268, has failed to operate.

Since the relay control logic circuit (FIG. 5) permits only a single instrument to be operated by power source 30 and prevents the remaining instruments from being connected to the power source, it is possible for an assistant to remove any one of the remaining instruments from the instrument tray for cleaning or other purposes without the danger of inadvertent operation of the instrument. Thus, while the doctor is using instrument 26 in an operation on a patient, his assistant can remove instrument 22 from instrument holder 36 to prepare it for use by the doctor with no possibility of accidental injury to the doctor, assistant, or patient.

When instrument 22 is removed from its holder, lever 56 is biased upward to move magnet 96 away from magnetic reed switch 76 to open its contacts. The opening of magnetic reed switch 76 has no effect on NAND gate 262 because the NAND gate, as previously explained, is inhibited by the binary "0" signal applied

to conductor 288 while instrument 26 is removed from its holder.

When instrument 26 is replaced on instrument holder 42, lever 52 is returned to its downward position and the contacts of magnetic reed switch 82 are closed by magnet 102. With magnetic reed switch 82 closed, a binary "0" input signal is applied to NAND gate 268 to change the output signal of the NAND gate from a binary "0" to a binary "1." The binary "1" output signal is applied to relay R_4 and conductor 268 through diodes 278. As a result, relay R_4 is de-energized to open relay contacts K_4 and to close relay contacts K_{4B} . The opening of relay contact K_4 disconnects instrument 26 from the power source while the closing of relay contacts K_{4B} has no effect on the binary "1" signal at output 325 because of the simultaneous change in the input signals applied to NAND gates 322 and 324 from NAND gate 268.

At the same time, the inhibiting binary "0" signal applied to NAND gate 262 by conductor 288 is changed to a binary "1" and the NAND gate produces a binary "0" signal which is applied to relay R_1 through diodes 272 to actuate the relay. The actuation of relay R_1 closes contacts K_1 (FIG. 3) to permit instrument 22 to be connected to power supply circuit 132 through motor speed control circuit 130 under the control of foot control switch 32.

The operation of the relay control logic circuit thus avoids the possibility of inadvertent operation of more than one instrument and, by permitting the remaining instruments to be removed from the instrument tray for preparation for subsequent operations, the circuit provides for rapid operation of the instruments in random sequence.

The invention in its broader aspects is not limited to the specific details shown and described, and modifications may be made in the details of the instrument control system without departing from the principles of the present invention.

What is claimed is:

1. A control system for selectively operating a plurality of powered instruments from a power source, comprising:

instrument supporting means including a plurality of instrument holders for receiving and holding the instruments;

sensing means for sensing removal of any one of the instruments from its holder; and

control means responsive to the sensing means for connecting the power source to an instrument when it is removed from its holder while at the same time preventing the remaining instruments from being operated by the power source.

2. The system of claim 1, wherein:

each instrument holder is mounted for movement from a first position when an instrument is placed therein to a second position when the instrument is removed therefrom; and

the sensing means comprises a plurality of switches mounted adjacent the instrument holders, each of the switches being actuated upon movement of its corresponding instrument holder from its first position to its second position when an instrument is removed therefrom.

3. The system of claim 2, wherein the control means comprises:

a plurality of relays for operatively connecting the instruments to the power source; and

a circuit connected to the switches and responsive to the actuation of any one of the switches upon removal of an instrument from its corresponding holder for operating the relay connected to the instrument removed to thereby connect the power source to said instrument and for preventing the remaining relays from being operated until the instrument is replaced in its holder.

4. A system for controlling the operation of a plurality of surgical instruments from a single power source to enable the instruments to be individually and selectively operated and to prevent inadvertent, simultaneous operation of more than one of the instruments, said system comprising:

an instrument tray including a plurality of instrument holders for receiving and holding the surgical instruments, each instrument holder being mounted for movement from a first position when an instrument is placed thereon to a second position when the instrument is removed therefrom

said instrument tray including sensing means responsive to movement of said instrument holders for sensing removal of any one of the surgical instruments from its holder; and

control means operatively connected to said sensing means for connecting the power source to an instrument removed from its holder while preventing the remaining instruments from being operated by the power source.

5. The system of claim 4, wherein said instrument tray comprises:

a base;

a frame mounted on said base;

each of said instrument holders being mounted on a lever pivotally mounted on the frame for movement between a first, downward position when an instrument is placed in the holder and a second, upward position when the instrument is removed from the holder; and

spring-bias means for biasing each lever into its upward position when an instrument is removed from its holder mounted thereon yet permitting said lever to move to its downward position when an instrument is replaced in the holder.

6. The system of claim 5, wherein:

said sensing means comprises a plurality of normally

open magnetic reed switches mounted on said base in alignment with said levers; and which includes

a magnet mounted on each lever for closing its corresponding magnetic reed switch when the lever is moved to its downward position, said control means being actuated to connect the power source to a removed instrument and to prevent the remaining instruments from being operated when its lever moved to its upward position and the switch returns to its normally open position.

7. The system of claim 5, wherein:

said sensing means comprises a plurality of microswitches mounted on said base in alignment with said levers and operatively engaged by said levers, each microswitch being actuated by movement of the corresponding lever.

8. The system of claim 7, wherein said control means comprises:

a plurality of relays for connecting the instruments to the power source; and

an electromechanical circuit connected to said microswitches for locating the microswitch actuated upon removal of an instrument from its holder and operating the relay connected to the instrument to connect the power source to the instrument and for preventing the remaining relays from being operated until the instrument is replaced in its holder.

9. The system of claim 5, which includes:

latching means for selectively securing each of said levers in its downward position to permit said instrument tray to be operated at less than full capacity.

10. The system of claim 5, including means for limiting upward movement of said levers when the instruments are removed from said instrument holders.

11. The system of claim 10, wherein said means for limiting upward movement of said levers comprises a plurality of adjustable stop bolts mounted on said frame and extending through slots in the levers to limit their upward movement upon removal of the instruments from said holders.

12. The system of claim 5, including a single operator controlled switch connected to the power source for controlling operation of the instrument removed from its holder and connected to the power source by the control means.

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